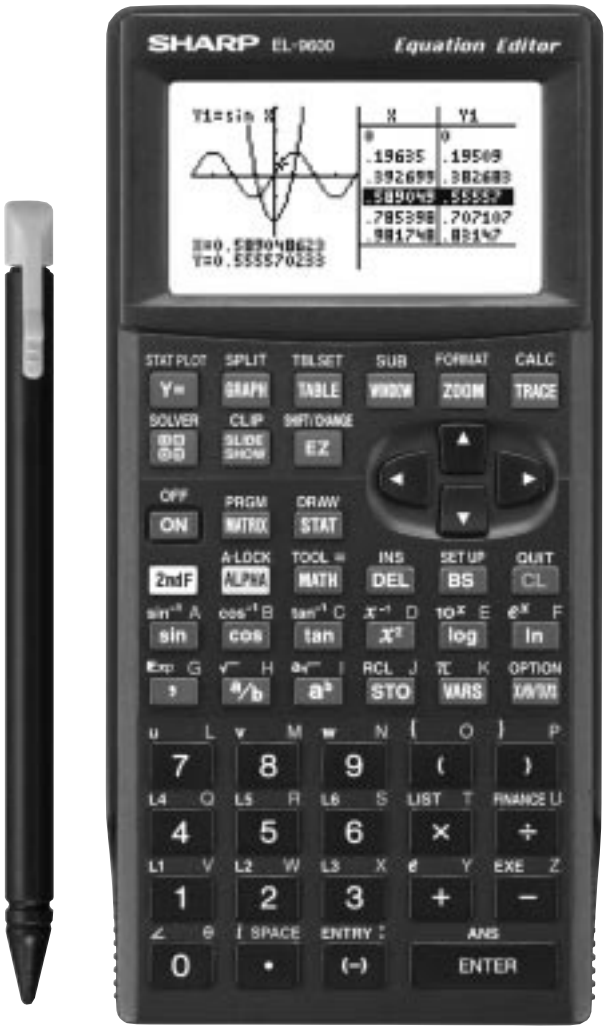
SHARP

Graphing Calculator

EL-9600/9400

Handbook Vol. 1

Algebra



EL-9600

EL-9400

Read this first

1. Always read "Before Start"

The key operations of the set up condition are written in "Before Start" in each section.
It is essential to follow the instructions in order to display the screens as they appear in the handbook.

2. Set Up Condition

As key operations for this handbook are conducted from the initial condition, reset all memories to the initial condition beforehand.

[2nd F] [OPTION] [E] [2] [CL]

Note: Since all memories will be deleted, it is advised to use the CE-LK1 PC link kit (sold separately) to back up any programmes not to be erased, or to return the settings to the initial condition (cf. 3. Initial Settings below) and to erase the data of the function to be used.

- To delete a single data, press [2nd F] [OPTION] [C] and select data to be deleted from the menu.
- Other keys to delete data:

[CL] : to erase equations and remove error displays
[2nd F] [QUIT] : to cancel previous function

3. Initial settings

Initial settings are as follows:

☆ Set up	([2nd F] [SET UP]):	Rad, FloatPt, 9, Rect, Decimal(Real), Equation
☆ Format	([2nd F] [FORMAT]):	RectCoord, OFF, OFF, Connect, Sequen
☆ Stat Plot	([2nd F] [STAT PLOT] [E]):	2. PlotOFF
Shade	([2nd F] [DRAW] [G]):	2. INITIAL
Zoom	([ZOOM] [A]):	5. Default
Period	([2nd F] [FINANCE] [C]):	1. PmtEnd

Note: ☆ returns to the default setting in the following operation.

([2nd F] [OPTION] [E] [1] [ENTER])

4. Using the keys

Press [2nd F] to use secondary functions (in yellow).

To select "$\sin^{-1}$": [2nd F] [sin] → Displayed as follows: [2nd F] [$\sin^{-1}$]

Press [ALPHA] to use the alphabet keys (in blue).

To select A: [ALPHA] [sin] → Displayed as follows: [ALPHA] [A]

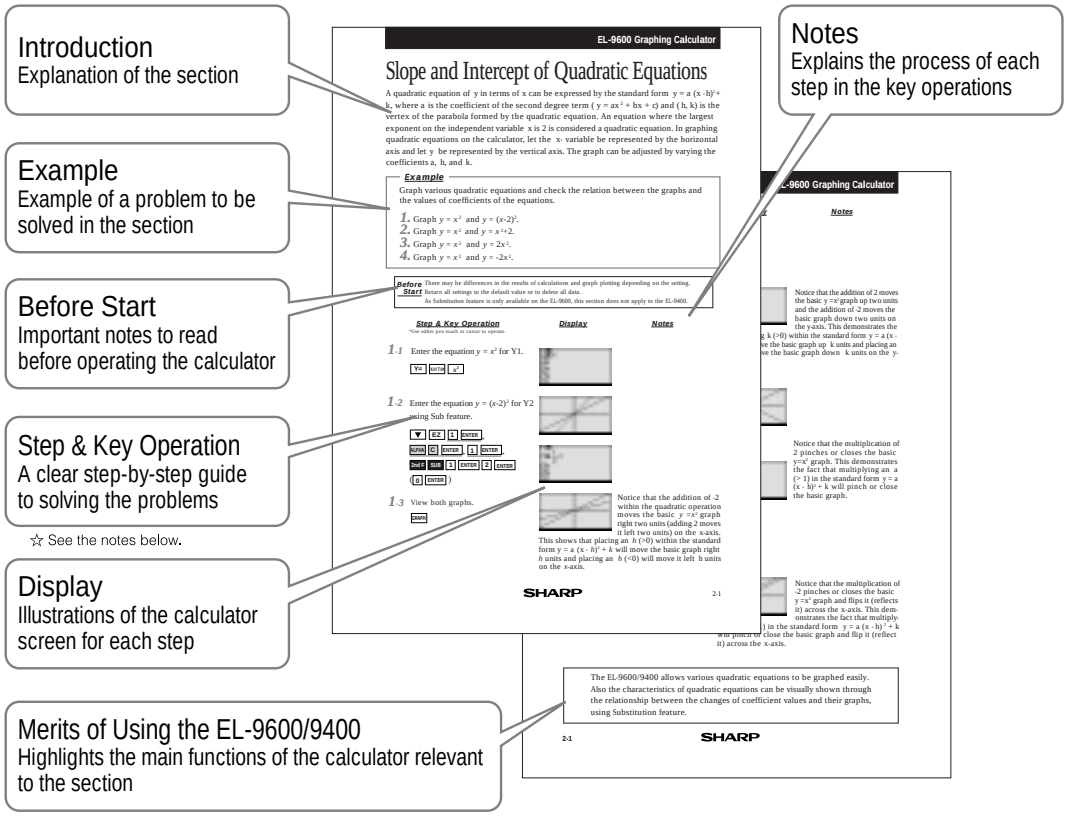
5. Notes

- Some features are provided only on the EL-9600 and not on the EL-9400. (Substitution, Solver, Matrix, Tool etc.)
- As this handbook is only an example of how to use the EL-9600 and 9400, please refer to the manual for further details.

SHARP

Using this Handbook

This handbook was produced for practical application of the SHARP EL-9600 and 9400 Graphing Calculator based on exercise examples received from teachers actively engaged in teaching. It can be used with minimal preparation in a variety of situations such as classroom presentations, and also as a self-study reference book.



☆ Notes on key operations

- When you see the sign ✱ on the key:
  ✱ means same series of key strokes can be done with screen touch on the EL-9600.
  (☐✱ : for the corresponding key; ☐☐☐✱ : for the corresponding keys underlined.)

  Key operations may also be carried out with the cursor (not shown).
- Different key appearance for the EL-9400: for example [XθT/n] → [X/T]

We would like to express our deepest gratitude to all the teachers whose cooperation we received in editing this book. We aim to produce a handbook which is more replete and useful to everyone, so any comments or ideas on exercise will be welcomed.

(Use the attached blank sheet to create and contribute your own mathematical problems.)

Thanks to Dr. David P. Lawrence at Southwestern Oklahoma State University for the use of his teaching resource book (Applying Pre-Algebra/Algebra using the SHARP EL-9600 Graphing Calculator).

Other books available:
Graphing Calculator EL-9600 TEACHERS' GUIDE
Graphing Calculator EL-9400 TEACHERS' GUIDE

SHARP

Contents

Slope and Intercept of Linear Equations

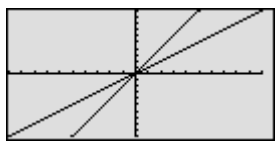
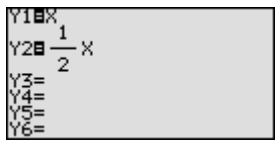
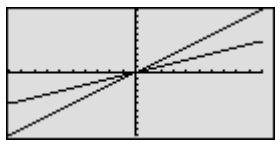
A linear equation of y in terms of x can be expressed by the slope-intercept form $y = mx+b$, where m is the slope and b is the y- intercept. We call this equation a linear equation since its graph is a straight line. Equations where the exponents on the x and y are 1 (implied) are considered linear equations. In graphing linear equations on the calculator, we will let the x variable be represented by the horizontal axis and let y be represented by the vertical axis.

Example

Draw graphs of two equations by changing the slope or the y- intercept.

1. Graph the equations $y = x$ and $y = 2x$.
2. Graph the equations $y = x$ and $y = \frac{1}{2}x$.
3. Graph the equations $y = x$ and $y = -x$.
4. Graph the equations $y = x$ and $y = x + 2$.

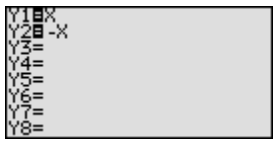
Before Start There may be differences in the results of calculations and graph plotting depending on the setting.
Return all settings to the default value or to delete all data.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Enter the equation $y = x$ for Y1 and $y = 2x$ for Y2. [Y=] [X/θ/T/n] [ENTER]* [2] [X/θ/T/n]		
1-2 View both graphs. [GRAPH]		The equation Y1 = x is displayed first, followed by the equation Y2 = $2x$. Notice how Y2 becomes steeper or climbs faster. Increase the size of the slope (m>1) to make the line steeper.
2-1 Enter the equation $y = \frac{1}{2}x$ for Y2. [Y=] [▼]* [CL] [1] [a/b] [2] [▶]* [X/θ/T/n]		
2-2 View both graphs. [GRAPH]		Notice how Y2 becomes less steep or climbs slower. Decrease the size of the slope (0<m<1) to make the line less steep.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

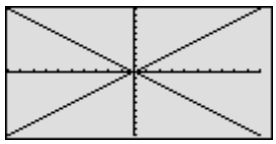
3-1 Enter the equation $y = -x$ for Y2.

[Y=] [▼]* [CL] [(-)] [X/θ/T/n]



3-2 View both graphs.

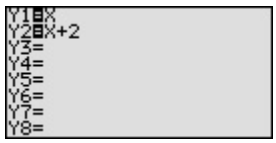
[GRAPH]



Notice how Y2 decreases (going down from left to right) instead of increasing (going up from left to right). Negative slopes ($m<0$) make the line decrease or go down from left to right.

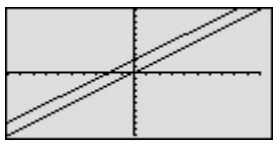
4-1 Enter the equation $y = x + 2$ for Y2.

[Y=] [▼]* [CL] [X/θ/T/n] [+] [2]



4-2 View both graphs.

[GRAPH]



Adding 2 will shift the $y = x$ graph upwards.

Making a graph is easy, and quick comparison of several graphs will help students understand the characteristics of linear equations.

SHARP

Parallel and Perpendicular Lines

Parallel and perpendicular lines can be drawn by changing the slope of the linear equation and the *y* intercept. A linear equation of *y* in terms of *x* can be expressed by the slope-intercept form $y = mx + b$, where m is the slope and b is the *y*-intercept.
Parallel lines have an equal slope with different *y*-intercepts. Perpendicular lines have slopes that are negative reciprocals of each other ($m = -\frac{1}{m}$). These characteristics can be verified by graphing these lines.

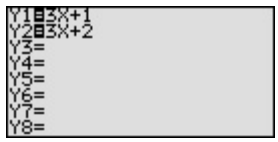
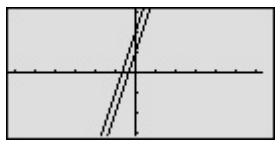
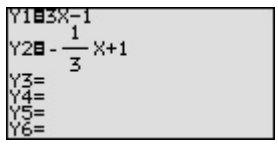
Example

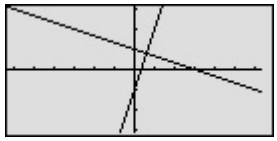
Graph parallel lines and perpendicular lines.

1. Graph the equations $y = 3x + 1$ and $y = 3x + 2$.
2. Graph the equations $y = 3x - 1$ and $y = -\frac{1}{3}x + 1$.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [C]* ([ENTER] [ALPHA] [▼]*) [7]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Enter the equations $y = 3x + 1$ for Y1 and $y = 3x + 2$ for Y2. [Y=] [3] [X/θ/T/n] [+] [1] [ENTER]* [3] [X/θ/T/n] [+] [2]		
1-2 View the graphs. [GRAPH]		These lines have an equal slope but different *y*- intercepts. They are called parallel, and will not intersect.
2-1 Enter the equations $y = 3x - 1$ for Y1 and $y = -\frac{1}{3}x + 1$ for Y2. [Y=] [CL] [3] [X/θ/T/n] [—] [1] [ENTER]* [CL] [(-)] [1] [a/b] [3] [▶]* [X/θ/T/n] [+] [1]		

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
2-2 View the graphs. **GRAPH**		These lines have slopes that are negative reciprocals of each other ($m = -\frac{1}{m}$). They are called perpendicular. Note that these intersecting lines form four equal angles.

The Graphing Calculators can be used to draw parallel or perpendicular lines while learning the slope or y-intercept of linear equations.

Slope and Intercept of Quadratic Equations

A quadratic equation of y in terms of x can be expressed by the standard form $y = a(x - h)^2 + k$, where a is the coefficient of the second degree term ($y = ax^2 + bx + c$) and (h, k) is the vertex of the parabola formed by the quadratic equation. An equation where the largest exponent on the independent variable x is 2 is considered a quadratic equation. In graphing quadratic equations on the calculator, let the x-variable be represented by the horizontal axis and let y be represented by the vertical axis. The graph can be adjusted by varying the coefficients a, h, and k.

Example

Graph various quadratic equations and check the relation between the graphs and the values of coefficients of the equations.

1. Graph $y = x^2$ and $y = (x - 2)^2$.
2. Graph $y = x^2$ and $y = x^2 + 2$.
3. Graph $y = x^2$ and $y = 2x^2$.
4. Graph $y = x^2$ and $y = -2x^2$.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Substitution feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes

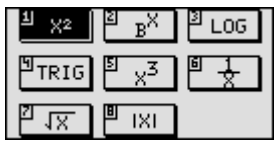
*Use either pen touch or cursor to operate.

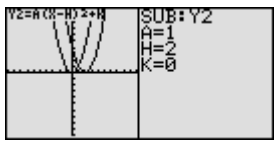
1-1 Enter the equation $y = x^2$ for Y1.

[Y=] [X/θ/T/n] [x^2]

1-2 Enter the equation $y = (x - 2)^2$ for Y2 using Sub feature.

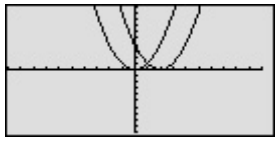
[▼] [EZ] [1] [ENTER]*
[ALPHA] [C] [ENTER]* [1] [ENTER]*
[2nd F] [SUB] [1] [ENTER] [2] [ENTER]
([0] [ENTER])





1-3 View both graphs.

[GRAPH]



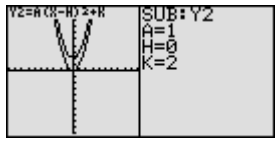
Notice that the addition of -2 within the quadratic operation moves the basic $y = x^2$ graph right two units (adding 2 moves it left two units) on the x-axis. This shows that placing an h (>0) within the standard form $y = a(x - h)^2 + k$ will move the basic graph right h units and placing an h (<0) will move it left h units on the x-axis.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-1 Change the equation in Y2 to $y = x^2+2$.

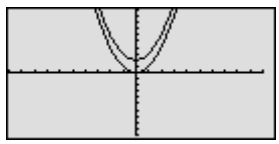
Y= ▼* 2nd F SUB ▼ 0

ENTER 2 ENTER



2-2 View both graphs.

GRAPH

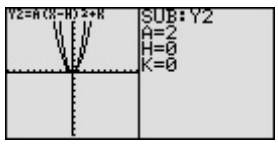


Notice that the addition of 2 moves the basic $y = x^2$ graph up two units and the addition of -2 moves the basic graph down two units on the y-axis. This demonstrates the fact that adding k (>0) within the standard form $y = a(x - h)^2 + k$ will move the basic graph up k units and placing an k (<0) will move the basic graph down k units on the y-axis.

3-1 Change the equation in Y2 to $y = 2x^2$.

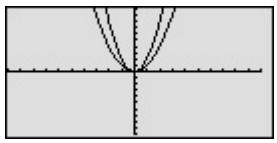
Y= ▼* 2nd F SUB 2 ENTER

▼ 0 ENTER



3-2 View both graphs.

GRAPH

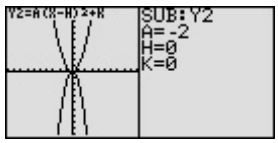


Notice that the multiplication of 2 pinches or closes the basic $y = x^2$ graph. This demonstrates the fact that multiplying an a (> 1) in the standard form $y = a(x - h)^2 + k$ will pinch or close the basic graph.

4-1 Change the equation in Y2 to $y = -2x^2$.

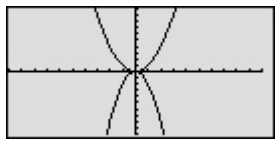
Y= ▼* 2nd F SUB (-) 2

ENTER



4-2 View both graphs.

GRAPH



Notice that the multiplication of -2 pinches or closes the basic $y = x^2$ graph and flips it (reflects it) across the x-axis. This demonstrates the fact that multiplying an a (<-1) in the standard form $y = a(x - h)^2 + k$ will pinch or close the basic graph and flip it (reflect it) across the x-axis.

The EL-9600/9400 allows various quadratic equations to be graphed easily. Also the characteristics of quadratic equations can be visually shown through the relationship between the changes of coefficient values and their graphs, using Substitution feature.

SHARP

Shifting a Graph of Quadratic Equations

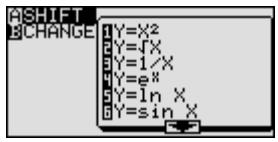
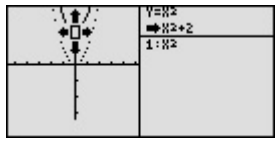
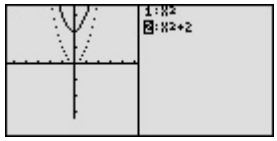
A quadratic equation of y in terms of x can be expressed by the standard form $y = a(x - h)^2 + k$, where a is the coefficient of the second degree term ($y = ax^2 + bx + c$) and (h, k) is the vertex of the parabola formed by the quadratic equation. An equation where the largest exponent on the independent variable x is 2 is considered a quadratic equation. In graphing quadratic equations on the calculator, let the x-variable be represented by the horizontal axis and let y be represented by the vertical axis. The relation of an equation and its graph can be seen by moving the graph and checking the coefficients of the equation.

Example

Move or pinch a graph of quadratic equation $y = x^2$ to verify the relation between the coefficients of the equation and the graph.

1. Shift the graph $y = x^2$ upward by 2.
2. Shift the graph $y = x^2$ to the right by 3.
3. Pinch the slope of the graph $y = x^2$.

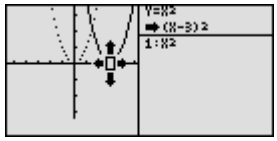
Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Access Shift feature and select the equation $y = x^2$. 2nd F SHIFT/CHANGE A * 1 *		
1-2 Move the graph $y = x^2$ upward by 2. ▲ ▲ ENTER *		
1-3 Save the new graph and observe the changes in the graph and the equation. ENTER ALPHA ▶ ▼		Notice that upward movement of the basic $y = x^2$ graph by 2 units in the direction of the y-axis means addition of 2 to the y-intercept. This demonstrates that upward movement of the graph by k units means adding a k (>0) in the standard form $y = a(x - h)^2 + k$.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

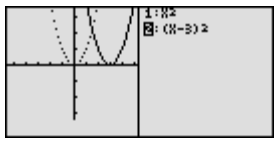
2-1 Move the graph $y = x^2$ to the right by 3.

CL ▶ (three times) ENTER*



2-2 Save the new graph and observe the changes in the graph and the equation

ENTER ALPHA ▶ ▼

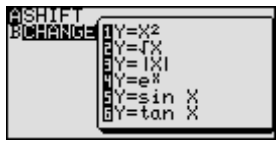


Notice that movement of the basic $y = x^2$ graph to the right by 3 units in the direction of the x-axis is equivalent to the addition of 3 to the x-intercept. This demonstrates that movement of the graph to the right means adding an h (>0) in the standard form $y = a\ (x - h)^2 + k$ and movement to the left means subtracting an h (<0).

3-1 Access Change feature and select the equation $y = x^2$.

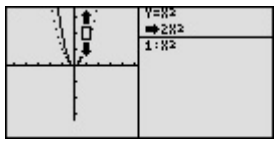
2nd F SHIFT/CHANGE B*

1*



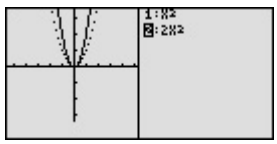
3-2 Pinch the slope of the graph.

▲ ENTER



3-3 Save the new graph and observe the changes in the graph and the equation.

ENTER ALPHA ▶ ▼



Notice that pinching or closing the basic $y = x^2$ graph is equivalent to increasing an a (>1) within the standard form $y = a\ (x - h)^2 + k$ and broadening the graph is equivalent to decreasing an a (<1).

The Shift/Change feature of the EL-9600/9400 allows visual understanding of how graph changes affect the form of quadratic equations.

Solving a Literal Equation Using the Equation Method (Amortization)

Solver mode is used to solve one unknown variable by inputting known variables, by three methods: Equation, Newton's, and Graphic. The Equation method is used when an exact solution can be found by simple substitution.

Example

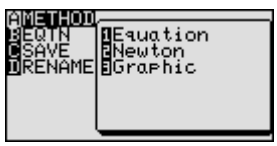
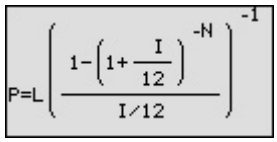
Solve an amortization formula. The solution from various values for known variables can be easily found by giving values to the known variables using Equation method in Solver mode.

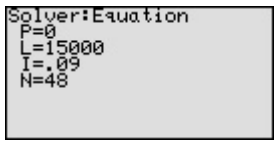
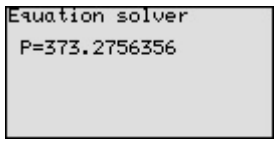
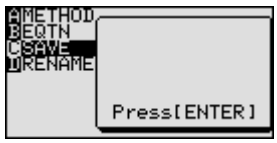
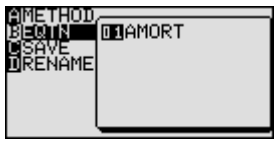
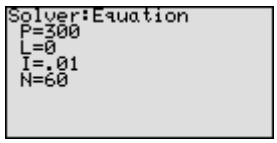
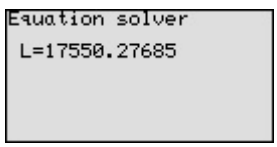
The formula : $P = L \left[\frac{1-(1+\frac{I}{12})^{-N}}{I / 12} \right]^{-1}$

P= monthly payment I= interest rate
L= loan amount N=number of months

1. Find the monthly payment on a $15,000 car loan, made at 9% interest over four years (48 months) using the Equation method.
2. Save the formula as "AMORT".
3. Find amount of loan possible at 7% interest over 60 months with a $300 payment, using the saved formula.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Solver feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	*Display*	*Notes*
*Use either pen touch or cursor to operate.		
***1**-1* Access the Solver feature. [2nd F] [SOLVER]		This screen will appear a few seconds after "SOLVER" is displayed.
***1**-2* Select the Equation method for solving. [2nd F] [SOLVER] [A]* [1]*		
***1**-3* Enter the amortization formula. [2nd F] [SOLVER] [P] [=] [L] [ALPHA] [(] [a/b] [1] [—] [(] [1] [+] [ALPHA] [1] [a/b] [1] [2] [▶]* [)] [a^b] [(-)] [ALPHA] [N] [▶] [▶]* [ALPHA] [I] [÷] [1] [2] [▶]* [)] [a^b] [(-)] [1]		

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-4 Enter the values L=15,000, I=0.09, N=48. ENTER ▼* 1 5 0 0 0 ENTER* • 0 9 ENTER* 4 8 ENTER		
1-5 Solve for the payment(P). ▲ ▲ ▲* 2nd F EXE (CL)		The monthly pay ment (P) is $373.28.
2-1 Save this formula. 2nd F SOLVER C* ENTER*		
2-2 Give the formula the name AMORT. A M O R T ENTER		
3-1 Recall the amortization formula. 2nd F SOLVER B* 0 1*		
3-2 Enter the values: P = 300, I = 0.01, N = 60 ENTER 3 0 0 ENTER 0 ENTER* • 0 1 ENTER* 6 1 ENTER		
3-3 Solve for the loan (L). ▲ ▲* 2nd F EXE		The amount of loan (L) is $17550.28.

With the Equation Editor, the EL-9600/9400 displays equations, even complicated ones, as they appear in the textbook in easy to understand format. Also it is easy to find the solution for unknown variables by recalling a stored equation and giving values to the known variables in Solver mode when using the EL-9600.

Solving a Literal Equation Using the Graphic Method (Volume of a Cylinder)

Solver mode is used to solve one unknown variable by inputting known variables. There are three methods: Equation, Newton's, and Graphic. The Equation method is used when an exact solution can be found by simple substitution. Newton's method implements an iterative approach to find the solution once a starting point is given. When a starting point is unavailable or multiple solutions are expected, use the Graphic method. This method plots the left and right sides of the equation and then locates the intersection(s).

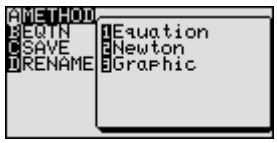
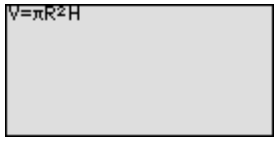
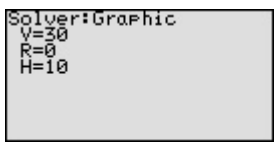
Example

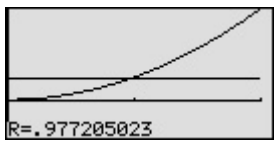
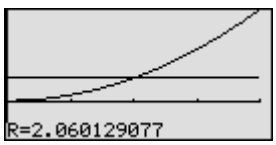
Use the Graphic method to find the radius of a cylinder giving the range of the unknown variable.

The formula : $V = \pi r^2 h$ (V = volume r = radius h = heiqht)

1. Find the radius of a cylinder with a volume of $30in^3$ and a height of 10in, using the Graphic method.
2. Save the formula as "V CYL".
3. Find the radius of a cylinder with a volume of $200in^3$ and a height of 15 in, using the saved formula.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Solver feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes
*Use either pen touch or cursor to operate.		
1-1 Access the Solver feature. 2nd F SOLVER		This screen will appear a few seconds after "SOLVER" is displayed.
1-2 Select the Graphic method for solving. 2nd F SOLVER A* 3*		
1-3 Enter the formula $V = \pi r^2 h$. ALPHA V ALPHA = 2nd F π ALPHA R x^2 ALPHA H		
1-4 Enter the values: V = 30, H = 10. Solve for the radius (R). ENTER 3 0 ENTER* ▼* 1 0 ENTER ▲* 2nd F EXE		

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-5 Set the variable range from 0 to 2. [0] [ENTER]* [2] [ENTER]	Graphic solver variable range BEGIN=0 END=2	The graphic solver will prompt with a variable range for solving. $r^2 = \frac{30}{10\pi} = \frac{3}{\pi} < 3$ $r = 1 \rightarrow r^2 = 1^2 = 1 < 3$ $r = 2 \rightarrow r^2 = 2^2 = 4 > 3$ Use the larger of the values to be safe.
1-6 Solve. [2nd F] [EXE] ([CL])	 R=.977205023	The solver feature will graph the left side of the equation (volume, $y = 30$), then the right side of the equation ($y = 10r^2$), and finally will calculate the intersection of the two graphs to find the solution. The radius is 0.98 in.
2 Save this formula. Give the formula the name "V CYL". [2nd F] [SOLVER] [C]* [ENTER]* [V] [SPACE] [C] [Y] [L] [ENTER]	TITLE:V CYL	
3-1 Recall the formula. Enter the values: V = 200, H = 15. [2nd F] [SOLVER] [B]* [0] [1]* [ENTER] [2] [0] [0] [ENTER] [0] [ENTER] [1] [5] [ENTER]	Solver:Graphic V=200 R=0 H=15	
3-2 Solve the radius setting the variable range from 0 to 4. [▲]* [2nd F] [EXE] [0] [ENTER] [0] [ENTER] [2nd F] [EXE]	 R=2.060129077	$r^2 = \frac{200}{15\pi} = \frac{14}{\pi} < 14$ $r = 3 \rightarrow r^2 = 3^2 = 9 < 14$ $r = 4 \rightarrow r^2 = 4^2 = 16 > 14$ Use 4, the larger of the values, to be safe. The answer is : $r = 2.06$

One very useful feature of the calculator is its ability to store and recall equations. The solution from various values for known variables can be easily obtained by recalling an equation which has been stored and giving values to the known variables. The Graphic method gives a visual solution by drawing a graph.

Solving a Literal Equation Using Newton's Method (Area of a Trapezoid)

Solver mode is used to solve one unknown variable by inputting known variables. There are three methods: Equation, Newton's, and Graphic. The Newton's method can be used for more complicated equations. This method implements an iterative approach to find the solution once a starting point is given.

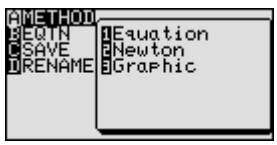
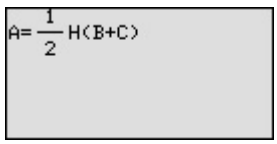
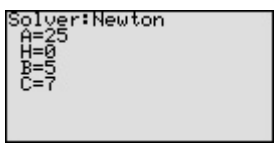
Example

Find the height of a trapezoid from the formula for calculating the area of a trapezoid useing Newton's method.

The formula : $A=\frac{1}{2}h(b+c)$ (A = area h = height b = top face c = bottom face)

1. Find the height of a trapezoid with an area of 25in^2 and bases of length 5 in and 7 in using Newton's method. (Set the starting point to 1.)
2. Save the formula as "A TRAP".
3. Find the height of a trapezoid with an area of 50in^2 with bases of 8 and 10 using the saved formula. (Set the starting point to 1.)

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Solver feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes
*Use either pen touch or cursor to operate.		
1-1 Access the Solver feature. 2nd F SOLVER		This screen will appear a few seconds after "SOLVER" is displayed.
1-2 Select Newton's method for solving. 2nd F SOLVER A* 2*		
1-3 Enter the formula A = $\frac{1}{2}h(b+c)$. ALPHA A ALPHA = 1 a/b 2 ▶* ALPHA H (ALPHA B + ALPHA C)		
1-4 Enter the values: A = 25, B = 5, C = 7 ENTER 2 5 ENTER* ▼* 5 ENTER* 7 ENTER		

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-5 Solve for the height and enter a starting point of 1. ▲ ▲* 2nd F EXE 1 ENTER	Newton solver START=1 STEP=.001	Newton's method will prompt with a guess or a starting point.
1-6 Solve. 2nd F EXE (CL)	Newton solver H=4.166666667 RIGHT=25 LEFT =25 L-R =-.000000002	The answer is : h = 4.17
2 Save this formula. Give the formula the name "A TRAP". 2nd F SOLVER C* ENTER A SPACE T R A P ENTER	TITLE:A TRAP	
3-1 Recall the formula for calculating the area of a trapezoid. 2nd F SOLVER B* 0 1	Solver:Equation A=50 H=0 B=8 C=10	
3-2 Enter the values: A = 50, B = 8, C = 10. ENTER 5 0 ENTER* ▼* 8 ENTER 1 0 ENTER	Solver:Newton A=50 H=4.166666667 B=8 C=10	
3-3 Solve. ▲ ▲* 2nd F EXE 1 ENTER 2nd F EXE	Newton solver H=5.555555556 RIGHT=50 LEFT =50 L-R =0	The answer is : h = 5.56

One very useful feature of the calculator is its ability to store and recall equations. The solution from various values for known variables can be easily obtained by recalling an equation which has been stored and giving values to the known variables in the Solver mode. If a starting point is known, Newton's method is useful for quick solution of a complicated equation.

Graphing Polynomials and Tracing to Find the Roots

A polynomial $y = f(x)$ is an expression of the sums of several terms that contain different powers of the same originals. The roots are found at the intersection of the x-axis and the graph i. e., when $y = 0$.

Example

Draw a graph of a polynomial and approximate the roots by using zoom-in and Trace features.

1. Graph the polynomial $y = x^3 - 3x^2 + x + 1$.
2. Approximate the left-hand root.
3. Approximate the middle root.
4. Approximate the right-hand root.

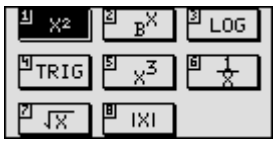
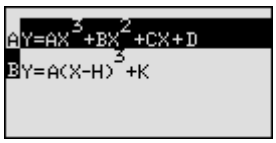
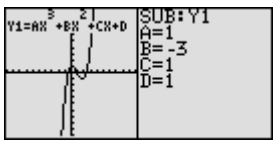
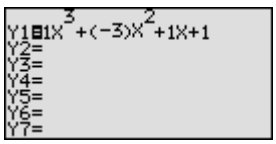
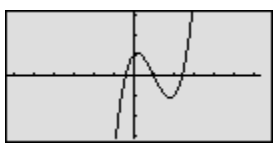
Before Start

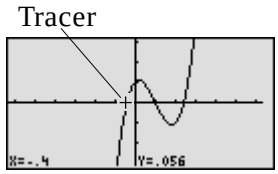
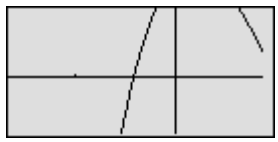
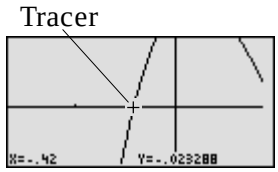
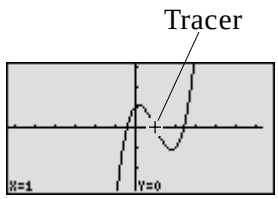
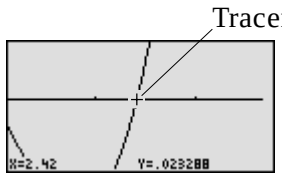
There may be differences in the results of calculations and graph plotting depending on the setting.
Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [ALPHA] [▼]*) [7]*

Setting the zoom factors to 5 : [ZOOM] [B]* [ENTER] [5] [ENTER] [5] [ENTER] [2nd F] [QUIT]

As Substitution feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes
*Use either pen touch or cursor to operate.		
1-1 Enter the polynomial $y = x^3 - 3x^2 + x + 1$. [Y=] [EZ] [5]* [ENTER]* [ENTER]* [ENTER]*	 	
1-2 Enter the coefficients. [2nd F] [SUB] [1] [ENTER]* [(-)] [3] [ENTER]* [1] [ENTER]* [1] [ENTER]		It may take few seconds for the graph to be drawn. Enter each coefficients when the cursor is displayed.
1-3 Return to the equation display screen. [2nd F] [EXE]		
1-4 View the graph. [GRAPH]		

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
2-1 Move the tracer near the left-hand root. TRACE ◀* (repeatedly)		Note that the tracer is flashing on the curve and the *x* and *y* coordinates are shown at the bottom of the screen.
2-2 Zoom in on the left-hand root. ZOOM A* 3*		
2-3 Move the tracer to approximate the root. TRACE ◀* or ▶* (repeatedly)		The root is : $x \fallingdotseq -0.42$
3-1 Return to the previous decimal viewing window. ZOOM H* 2*		
3-2 Move the tracer to approximate the middle root. TRACE ▶* (repeatedly)		The root is exactly $x = 1$. (Zooming is not needed to find a better approximate.)
4 Move the tracer near the right-hand root. Zoom in and move the tracer to find a better approximate. ▶* (repeatedly) ZOOM A* 3* TRACE ▶* or ◀* (repeatedly)		The root is : $x \fallingdotseq 2.42$

The calculator allows the roots to be found (or approximated) visually by graphing a polynomial and using the Zoom-in and Trace features.

Graphing Polynomials and Jumping to Find the Roots

A polynomial $y = f(x)$ is an expression of the sums of several terms that contain different powers of the same originals. The roots are found at the intersection of the x-axis and the graph i. e., when $y = 0$.

Example

Draw a graph of a polynomial and find the roots by using the Calculate feature.

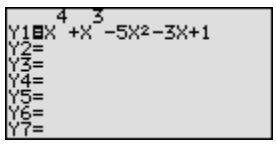
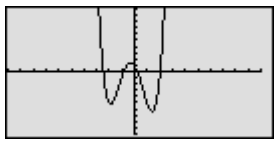
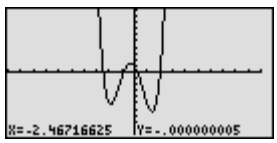
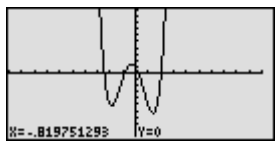
1. Graph the polynomial $y = x^4 + x^3 - 5x^2 - 3x + 1$.

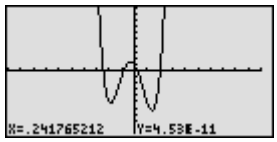
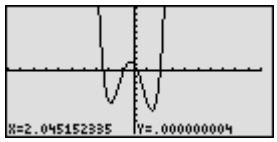
2. Find the four roots one by one.

Before Start

There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Setting the zoom factors to 5 : [ZOOM] [A]* [ENTER] [A] [ENTER] [A] [ENTER] [2nd F] [QUIT]

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Enter the polynomial $y = x^4 + x^3 - 5x^2 - 3x + 1$ [Y=] [X/θ/T/n] [a^b] [4] [▶]* [+] [X/θ/T/n] [a^b] [3] [▶]* [—] [5] [X/θ/T/n] [x^2] [—] [3] [X/θ/T/n] [+] [1]		
1-2 View the graph. [GRAPH]		
2-1 Find the first root. [2nd F] [CALC] [5]*	 	$x \fallingdotseq -2.47$ Y is almost but not exactly zero. Notice that the root found here is an approximate value.
2-2 Find the next root. [2nd F] [CALC] [5]*		$x \fallingdotseq -0.82$

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
2-3 Find the next root. **2nd F** **CALC** **5** *		$x \fallingdotseq 0.24$
2-4 Find the next root. **2nd F** **CALC** **5** *		$x \fallingdotseq 2.05$

The calculator allows jumping to find the roots by graphing a polynomial and using the Calculate feature, without tracing the graph.

Solving a System of Equations by Graphing or Tool Feature

A system of equations is made up of two or more equations. The calculator provides the Calculate feature and Tool feature to solve a system of equations. The Calculate feature finds the solution by calculating the intersections of the graphs of equations and is useful for solving a system when there are two variables, while the Tool feature can solve a linear system up to six variables and six equations.

Example

Solve a system of equations using the Calculate or Tool feature. First, use the Calculate feature. Enter the equations, draw the graph, and find the intersections. Then, use the Tool feature to solve a system of equations.

1. Solve the system using the Calculate feature.

$$\begin{cases} y = x^2 - 1 \\ y = 2x \end{cases}$$

2. Solve the system using the Tool feature.

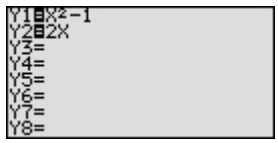
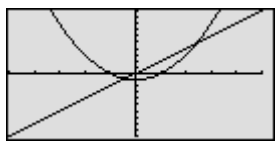
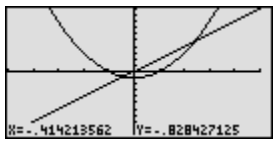
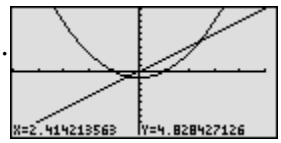
$$\begin{cases} 5x + y = 1 \\ -3x + y = -5 \end{cases}$$

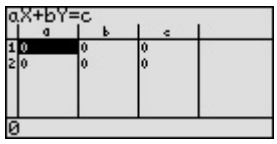
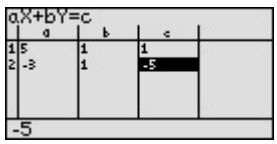
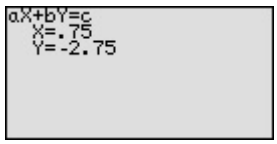
Before Start

There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
Choose the viewing window "-5 < X < 5", "-10 < Y < 10" using Rapid window feature

[WINDOW] [EZ] [5]* [ENTER]* ([ALPHA] [▼]) [7]* [ENTER]* [4]* [ENTER]*

As Tool feature is only available on the EL-9600, the example 2 does not apply to the EL-9400.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Enter the system of equations $y = x^2 - 1$ for Y1 and $y = 2x$ for Y2. [Y=] [X/θ/T/n] [x^2] [—] [1] [ENTER]* [2] [X/θ/T/n]		
1-2 View the graphs. [GRAPH]		
1-3 Find the left-hand intersection using Calculate feature. [2nd F] [CALC] [2]*		Note that the x and y coordinates are shown at the bottom of the screen. The answer is : $x = -0.41$ $y = -0.83$
1-4 Find the right-hand intersection by accessing the Calculate feature again. [2nd F] [CALC] [2]*		The answer is : $x = 2.41$ $y = 4.83$

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
2-1 Access the Tool menu. Select the number of variables. 2nd F TOOL B* 2*		Using system function, it is possible to solve simultaneous linear equations. Systems up to six variables and six equations can be solved.
2-2 Enter the system of equations. 5 ENTER 1 ENTER 1 ENTER (-) 3 ENTER 1 ENTER (-) 5 ENTER		
2-3 Solve the system. 2nd F EXE		x = 0.75 y = -2.75

A system of equations can be solved easily by using the Calculate feature or Tool feature.

Entering and Multiplying Matrices

A matrix is a rectangular array of elements in rows and columns that is treated as a single element. A matrix is often used for expressing multiple linear equations with multiple variables.

Example

Enter two matrices and execute multiplication of the two.

1. Enter a 3x3 matrix A
2. Enter a 3x3 matrix B
3. Multiply the matrices A and B

$$A = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & -1 \\ 1 & 1 & -2 \end{bmatrix} \qquad B = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Matrix feature is only available on the EL-9600, this section does not apply to the EL-9400.

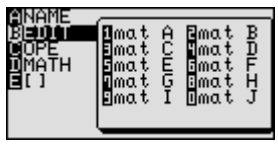
Step & Key Operation	***Display***	***Notes***

*Use either pen touch or cursor to operate.

1-1 Access the matrix menu.

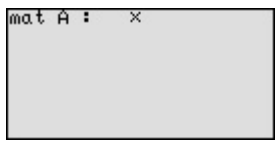
[MATRIX] [B]*

[1]*



1-2 Set the dimension of the matrix at three rows by three columns.

[3] [ENTER] [3] [ENTER]

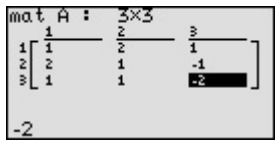


1-3 Enter the elements of the first row, the elements of the second row, and the elements of the third row.

[1] [ENTER] [2] [ENTER] [1] [ENTER]

[2] [ENTER] [1] [ENTER] [(-)] [1] [ENTER]

[1] [ENTER] [1] [ENTER] [(-)] [2] [ENTER]



Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2 Enter a 3×3 matrix B.

[MATRIX] [B]* [2]* [3] [ENTER] [3] [ENTER]

[1] [ENTER] [2] [ENTER] [3] [ENTER]

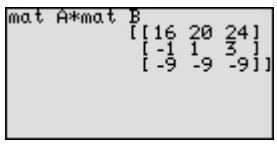
[4] [ENTER] [5] [ENTER] [6] [ENTER]

[7] [ENTER] [8] [ENTER] [9] [ENTER]

3-1 Multiply the matrices A and B together at the home screen.

[▦] [MATRIX] [A]* [1]* [×] [MATRIX]

[A]* [2]* [ENTER]



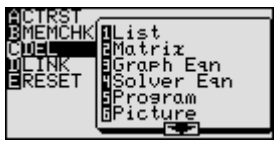
Matrix multiplication can be performed if the number of columns of the first matrix is equal to the number of rows of the second matrix. The sum of these multiplications (1•1 + 2•4 + 1•7) is placed in the 1,1 (first row, first column) position of the resulting matrix. This process is repeated until each row of A has been multiplied by each column of B.

3-2 Delete the input matrices for future use.

[2nd F] [OPTION] [C]*

[2]* [ENTER] [ENTER]

[2nd F] [QUIT]



Matrix multiplication can be performed easily by the calculator.

SHARP

Solving a System of Linear Equations Using Matrices

Each system of three linear equations consists of three variables. Equations in more than three variables cannot be graphed on the graphing calculator. The solution of the system of equations can be found numerically using the Matrix feature or the System solver in the Tool feature.

A system of linear equations can be expressed as AX = B (A, X and B are matrices). The solution matrix X is found by multiplying $A^{-1}B$. Note that the multiplication is "order sensitive" and the correct answer will be obtained by multiplying BA^{-1}. An inverse matrix A^{-1} is a matrix that when multiplied by A results in the identity matrix I ($A^{-1} \times A = I$). The identity matrix I is defined to be a square matrix ($n \times n$) where each position on the diagonal is 1 and all others are 0.

Example

Use matrix multiplication to solve a system of linear equations.

1. Enter the 3×3 identity matrix in matrix A.

2. Find the inverse matrix of the matrix B.

3. Solve the equation system.

$$\begin{cases} x + 2y + z = 8 \\ 2x + y - z = 1 \\ x + y - 2z = -3 \end{cases}$$

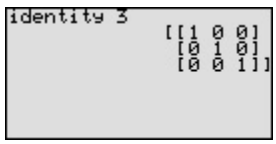
$$B = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & -1 \\ 1 & 1 & -2 \end{bmatrix}$$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.
As Matrix feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes
*Use either pen touch or cursor to operate.		

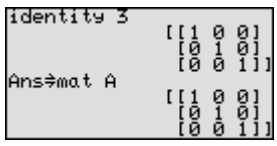
1-1 Set up 3×3 identity matrix at the home screen.

[⊞] [MATRIX] [C]* [0] [5]* [3] [ENTER]



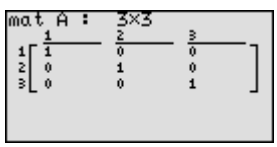
1-2 Save the identity matrix in matrix A.

[STO] [MATRIX] [A]* [1]* [ENTER]



1-3 Confirm that the identity matrix is stored in matrix A.

[MATRIX] [B]* [1]*



Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

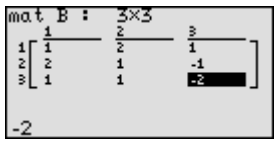
2-1 Enter a 3×3 matrix B.

MATRIX B* 2* 3 ENTER 3 ENTER

1 ENTER 2 ENTER 1 ENTER

2 ENTER 1 ENTER (-) 1 ENTER

1 ENTER 1 ENTER (-) 2 ENTER

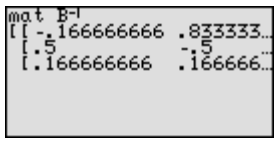


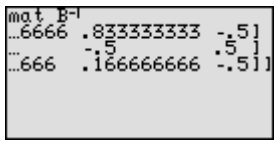
2-2 Exit the matrix editor and find the inverse of the square matrix B.

2nd F QUIT CL

MATRIX A* 2* 2nd F x^{-1} ENTER

▶ (repeatedly)





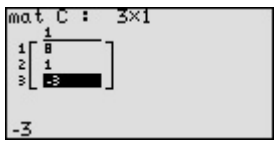
Some square matrices have no inverse and will generate error statements when calculating the inverse.

$$B^{-1}=\begin{bmatrix} -0.17 & 0.83 & -0.5 \\ 0.5 & -0.5 & 0.5 \\ 0.17 & 0.17 & -0.5 \end{bmatrix}$$

3-1 Enter the constants on the right side of the equal sign into matrix C (3×1).

MATRIX B* 3* 3 ENTER 1 ENTER

8 ENTER 1 ENTER (-) 3 ENTER



The system of equations can be expressed as

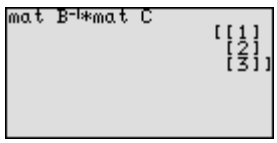
$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & -1 \\ 1 & 1 & -2 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix}=\begin{bmatrix} 8 \\ 1 \\ -3 \end{bmatrix}$$

Let each matrix B, X, C :
$BX = C$
$B^{-1}BX = B^{-1}C$ (multiply both sides by B^{-1})
$I = B^{-1}$ ($B^{-1}B = I$, identity matrix)
$X = B^{-1}C$

3-2 Calculate $B^{-1}C$.

CL MATRIX A* 2*

2nd F x^{-1} × MATRIX A* 3* ENTER



The 1 is the *x* coordinate, 2 the *y* coordinate, and the 3 the *z* coordinate of the solution point.
(*x*, *y*, *z*)=(1, 2, 3)

3-3 Delete the input matrices for future use.

2nd F OPTION C*

2* ENTER

2nd F QUIT

The calculator can execute calculation of inverse matrix and matrix multiplication. A system of linear equations can be solved easily using the Matrix feature.

Solving Inequalities

To solve an inequality, expressed by the form of $f(x) \leq 0$, $f(x) \geq 0$, or form of $f(x) \leq g(x)$, $f(x) \geq g(x)$, means to find all values that make the inequality true.

There are two methods of finding these values for one-variable inequalities, using graphical techniques. The first method involves rewriting the inequality so that the right-hand side of the inequality is 0 and the left-hand side is a function of x. For example, to find the solution to $f(x) < 0$, determine where the graph of $f(x)$ is below the x-axis. The second method involves graphing each side of the inequality as an individual function. For example, to find the solution to $f(x) < g(x)$, determine where the graph of $f(x)$ is below the graph of $g(x)$.

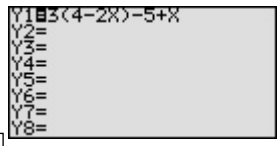
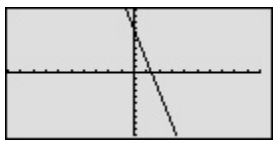
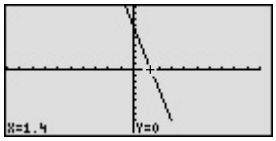
Example

Solve an inequality in two methods.

1. Solve $3(4 - 2x) \geq 5 - x$, by rewriting the right-hand side of the inequality as 0.

2. Solve $3(4 - 2x) \geq 5 - x$, by shading the solution region that makes the inequality true.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

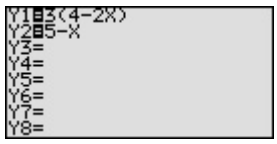
Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Rewrite the equation $3(4 - 2x) \geq 5 - x$ so that the right-hand side becomes 0, and enter $y = 3(4 - 2x) - 5 + x$ for Y1. [Y=] [3] [(] [4] [—] [2] [X/θ/T/n] [)] [—] [5] [+] [X/θ/T/n]		$3(4 - 2x) \geq 5 - x$ → $3(4 - 2x) - 5 + x \geq 0$
1-2 View the graph. [GRAPH]		
1-3 Find the location of the x-intercept and solve the inequality. [2nd F] [CALC] [5]*	 	The x-intercept is located at the point (1.4, 0). Since the graph is above the x-axis to the left of the x-intercept, the solution to the inequality $3(4 - 2x) - 5 + x \geq 0$ is all values of x such that $x \leq 1.4$.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes

2-1 Enter $y = 3(4 - 2x)$ for Y1 and $y = 5 - x$ for Y2.

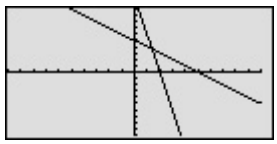
[Y=] [▶]* (7 times) [DEL] (4 times)

[ENTER]* [5] [—] [X/θ/T/n]



2-2 View the graph.

[GRAPH]



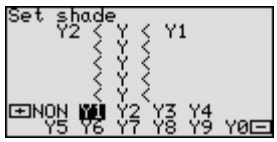
2-3 Access the Set Shade screen.

[2nd F] [DRAW] [G]*

[1]*

2-4 Set up the shading.

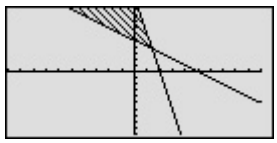
[—] [—]* [▶]* [—]*



Since the inequality being solved is Y1 ≥ Y2, the solution is where the graph of Y1 is "on the top" and Y2 is "on the bottom."

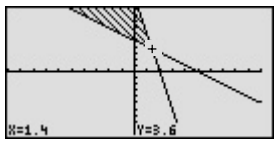
2-5 View the shaded region.

[GRAPH]



2-6 Find where the graphs intersect and solve the inequality.

[2nd F] [CALC] [2]*



The point of intersection is (1.4, 3.6). Since the shaded region is to the left of $x = 1.4$, the solution to the inequality $3(4 - 2x) \geq 5 - x$ is all values of x such that $x \leq 1.4$.

Graphical solution methods not only offer instructive visualization of the solution process, but they can be applied to inequalities that are often difficult to solve algebraically. The EL-9600/9400 allows the solution region to be indicated visually using the Shade feature. Also, the points of intersection can be obtained easily.

Solving Double Inequalities

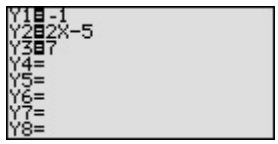
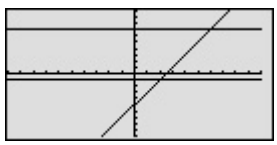
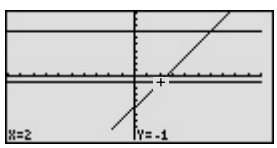
The solution to a system of two inequalities in one variable consists of all values of the variable that make each inequality in the system true. A system $f(x) \geq a, f(x) \leq b$, where the same expression appears on both inequalities, is commonly referred to as a "double" inequality and is often written in the form $a \leq f(x) \leq b$. Be certain that both inequality signs are pointing in the same direction and that the double inequality is only used to indicate an expression in x "trapped" in between two values. Also a must be less than or equal to b in the inequality $a \leq f(x) \leq b$ *or* $b \geq f(x) \geq a$.

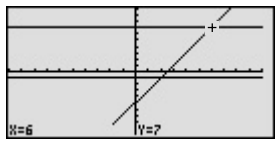
Example

Solve a double inequality, using graphical techniques.

$2x - 5 \geq -1$
$2x - 5 \geq 7$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Step & Key Operation	Display	Notes
(When using EL-9600) *Use either pen touch or cursor to operate.	(When using EL-9600)	
1 Enter $y = -1$ for Y1, $y = 2x - 5$ for Y2, and $y = 7$ for Y3. Y= (-) 1 ENTER* 2 X/θ/T/n — 5 ENTER* 7		The "double" inequality given can also be written to $-1 \leq 2x - 5 \leq 7$.
2 View the lines. GRAPH		
3 Find the point of intersection. 2nd F CALC 3*	 	$y = 2x - 5$ and $y = -1$ intersect at (2, -1).

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
4 Move the tracer and find another intersection. ▲ 2nd F CALC 2*		$y = 2x - 5$ and $y = 7$ intersect at (6,7).
5 Solve the inequalities.		The solution to the "double" inequality $-1 \leq 2x - 5 \leq 7$ consists of all values of x in between, and including, 2 and 6 (i.e., $x \geq 2$ and $x \leq 6$). The solution is $2 \leq x \leq 6$.

Graphical solution methods not only offer instructive visualization of the solution process, but they can be applied to inequalities that are often difficult to solve algebraically. The EL-9600/9400 allows the solution region to be indicated visually using the Shade feature. Also, the points of intersection can be obtained easily.

System of Two-Variable Inequalities

The solution region of a system of two-variable inequalities consists of all points (a, b) such that when $x = a$ and $y = b$, all inequalities in the system are true. To solve two-variable inequalities, the inequalities must be manipulated to isolate the y variable and enter the other side of the inequality as a function. The calculator will only accept functions of the form $y =$ ___. (where y is defined explicitly in terms of x).

Example

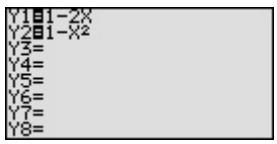
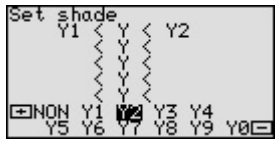
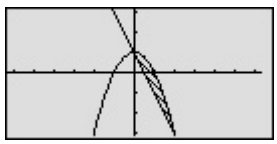
Solve a system of two-variable inequalities by shading the solution region.

$2x + y \geq 1$

$x^2 + y \leq 1$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [2nd F] [▼]*) [7]

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1 Rewrite each inequality in the system so that the left-hand-side is y :		$2x + y \geq 1 \rightarrow y \geq 1 - 2x$ $x^2 + y \leq 1 \rightarrow y \leq 1 - x^2$
2 Enter $y = 1 - 2x$ for Y1 and $y = 1 - x^2$ for Y2. [Y=] [1] [—] [2] [X/θ/T/n] [ENTER]* [1] [—] [X/θ/T/n] [x^2]		
3 Access the set shade screen [2nd F] [DRAW] [G]* [1]*		
4 Shade the points of y -value so that $Y1 \leq y \leq Y2$. [—]* [▶]* [—] [—]*		
5 Graph the system and find the intersections. [GRAPH] [2nd F] [CALC] [2]* [2nd F] [CALC] [2]*		The intersections are (0, 1) and (2, -3)
6 Solve the system.		The solution is $0 \leq x \leq 2$.

Graphical solution methods not only offer instructive visualization of the solution process, but they can be applied to inequalities that are often difficult to solve algebraically. The EL-9600/9400 allows the solution region to be indicated visually using the Shade feature. Also, the points of intersection can be obtained easily.

Graphing Solution Region of Inequalities

The solution region of an inequality consists of all points (a, b) such that when $x = a$, and $y = b$, all inequalities are true.

Example

Check to see if given points are in the solution region of a system of inequalities.

1. Graph the solution region of a system of inequalities:

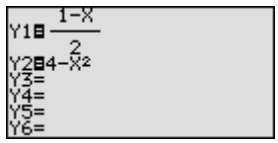
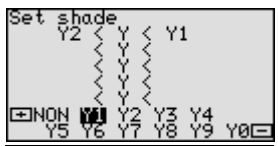
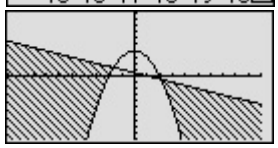
$x + 2y \leq 1$

$x^2 + y \geq 4$

2. Which of the following points are within the solution region?

(-1.6, 1.8), (-2, -5), (2.8, -1.4), (-8,4)

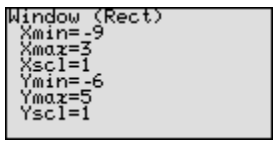
Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Rewrite the inequalities so that the left-hand-side is y.		$x + 2y \leq 1 \rightarrow y \leq \frac{1-x}{2}$ $x^2+y \geq 4 \rightarrow y \geq 4 - x^2$
1-2 Enter $y = \frac{1-x}{2}$ for Y1 and $y = 4 - x^2$ for Y2. Y= a/b 1 — X/θ/T/∩ ▼ 2 ENTER* 4 — X/θ/T/∩ x^2		
1-3 Set the shade and view the solution region. 2nd F DRAW G* 1 —* —* ▶* —* GRAPH	 	Y2 ≤ y ≤ Y1

2-1 Set the display area (window) to : $-9 < x < 3$, $-6 < y < 5$.

WINDOW (-) 9 ENTER 3 ENTER

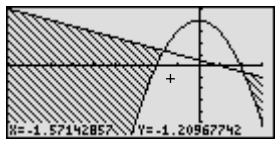
ENTER (-) 6 ENTER 5 ENTER



Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-2 Use the cursor to check the position of each point. (Zoom in as necessary).

GRAPH ▶ or ◀ or ▲ or ▼



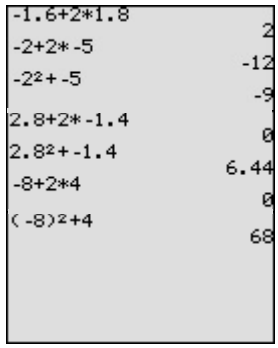
Points in the solution region are (2.8, -1.4) and (-8, 4). Points outside the solution region are (-1.6, 1.8) and (-2, -5).

2-3 Substitute points and confirm whether they are in the solution region.

⊞ (-) 1 • 6 +

2 × 1 • 8 • • •

(Continuing key operations omitted.)



•(-1.6, 1.8): $-1.6 + 2 \times 1.8 = 2$
→ This does not materialize.
•(-2, -5): $-2 + 2 \times (-5) = -12$
$(-2)^2 + (-5) = -1$
→ This does not materialize.
•(2.8, -1.4): $2.8 + 2 \times (-1.4) = 0$
$(2.8)^2 + (-1.4) = 6.44$
→ This materializes.
•(-8, 4): $-8 + 2 \times 4 = 0$
$(-8)^2 + 4 = 68$
→ This materializes.

Graphical solution methods not only offer instructive visualization of the solution process, but they can be applied to inequalities that are often very difficult to solve algebraically. The EL-9600/9400 allows the solution region to be indicated visually using the Shading feature. Also, the free-moving tracer or Zoom-in feature will allow the details to be checked visually.

Slope and Intercept of Absolute Value Functions

The absolute value of a real number x is defined by the following:

$$|x| = \begin{cases} x & \text{if } x \geq 0 \\ -x & \text{if } x \leq 0 \end{cases}$$

If n is a positive number, there are two solutions to the equation $|f(x)| = n$ because there are exactly two numbers with the absolute value equal to n: n and $-n$. The existence of two distinct solutions is clear when the equation is solved graphically.

An absolute value function can be presented as $y = a|x - h| + k$. The graph moves as the changes of slope a, x-intercept h, and y-intercept k.

Example

Consider various absolute value functions and check the relation between the graphs and the values of coefficients.

1. Graph $y = |x|$

2. Graph $y = |x - 1|$ and $y = |x| - 1$ using Rapid Graph feature.

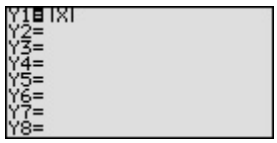
Before Start

There may be differences in the results of calculations and graph plotting depending on the setting.
Return all settings to the default value or to delete all data.
Set the zoom to the decimai window: [ZOOM] [A]* ([ENTER] [2nd F] [▼]*) [7]
As Substitution feature is only available on the EL-9600, this section does not apply to the EL-9400.

Step & Key Operation	Display	Notes
*Use either pen touch or cursor to operate.		

1-1 Enter the function $y = |x|$ for Y1.

[Y=] [MATH] [B]* [1]* [X/θ/T/n]



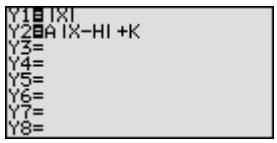
1-2 View the graph.

[GRAPH]

Notice that the domain of $f(x) = |x|$ is the set of all real numbers and the range is the set of non-negative real numbers. Notice also that the slope of the graph is 1in the range of $X > 0$ and -1in the range of $X \leq 0$.

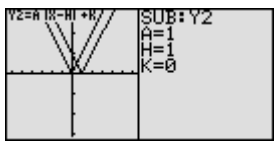
2-1 Enter the standard form of an absolute value function for Y2 using Rapid Graph feature.

[Y=] [▼] [EZ] [8]* [ENTER]* [ENTER]* [ENTER]*



2-2 Substitute the coefficients to graph $y = |x - 1|$.

[2nd F] [SUB] [1] [ENTER] [1] [ENTER] [0] [ENTER]

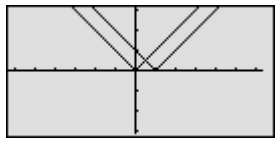


SHARP

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-3 View the graph.

GRAPH

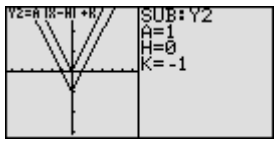


Notice that placing an h (>0) within the standard form $y = a|x - h| + k$ will move the graph right h units on the x-axis.

2-4 Change the coefficients to graph $y = |x| - 1$.

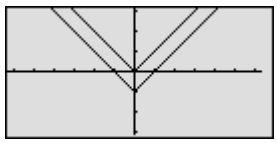
Y= ▼ 2nd F SUB ENTER 1

ENTER (-) 1 ENTER



2-5 View the graph.

GRAPH



Notice that adding a k (>0) within the standard form $y=a|x-h|+k$ will move the graph up k units on the y-axis.

The EL-9600/9400 shows absolute values with | | just as written on paper by using the Equation editor. Use of the calculator allows various absolute value functions to be graphed quickly and shows their characteristics in an easy-to-understand manner.

Shifting a graph of Absolute Value Functions

The absolute value of a real number x is defined by the following:

$$|x| = \begin{cases} x & \text{if } x \geq 0 \\ -x & \text{if } x \leq 0 \end{cases}$$

If n is a positive number, there are two solutions to the equation $|f(x)| = n$ because there are exactly two numbers with the absolute value equal to n: n and $-n$. The existence of two distinct solutions is clear when the equation is solved graphically.

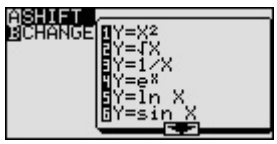
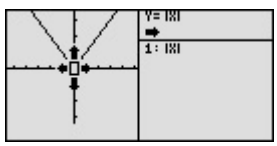
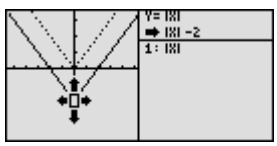
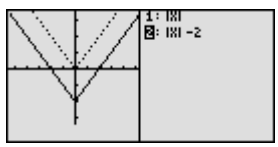
An absolute value function can be presented as $y = a|x - h| + k$. The graph moves as the changes of slope a, x-intercept h, and y-intercept k.

Example

Move and change graphs of absolute value function $y = |x|$ to check the relation between the graphs and the values of coefficients.

1. Move the graph $y = |x|$ downward by 2 using the Shift feature.
2. Move the graph $y = |x|$ to the right by 2 using the Shift feature.
3. Pinch the slope of $y = |x|$ to 2 or minus using the Change feature.

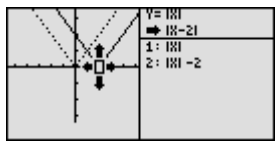
Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Access the Shift feature. Select $y = \|x\|$. 2nd F SHIFT/CHANGE A* (ENTER ALPHA ▼*)8*	 	
1-2 Move the graph downward by 2. ▼ ▼ ENTER*		$y = \|x\|$ changes to $y = \|x\| - 2$
1-3 Save the new graph and look at the relationship of the function and the graph. ENTER ALPHA ▶ ▼		The graph of the equation that is highlighted is shown by a solid line. Notice that the y-intercept k in the standard form $y = a\|x - h\| + k$ takes charge of vertical movement of the graph.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-1 Move the original graph to the right by 2.

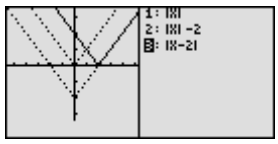
▲ ALPHA ◀* ▶ ▶ ENTER*



$y = |x|$ changes to $y = |x-2|$

2-2 Save the new graph and look at the relationship of the function and the graph.

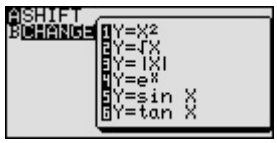
ENTER ALPHA ▶* ▼ ▼*



Notice that the function h in the standard form $y = a|x - h| + k$ takes charge of horizontal movement of the graph.

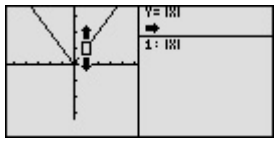
3-1 Access the Change feature.

2nd F SHIFT/CHANGE B*



3-2 Select $y = |x|$.

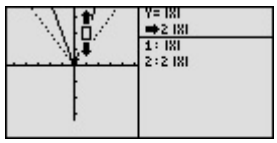
3*



3-3 Make the slope of the graph steeper. Save the new graph.

▲ ENTER

ENTER

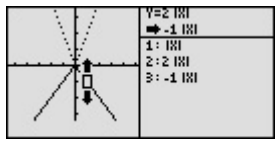


$y = |x| \rightarrow y = 2|x|$

3-4 Make the slope of the graph minus. Save the new graph.

▼ ▼ ▼ ENTER

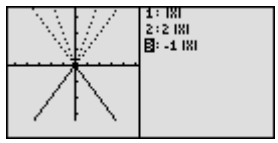
ENTER



$y = |x| \rightarrow y = -|x|$

3-5 Look at the relationship of the function and the graph.

ALPHA ▶* ▼* ▼*



Notice that the coefficient a in the standard form $y = a|x - h| + k$ takes charge of changing the slope.

EL-9600/9400 shows absolute values with | | just as written on paper by using the Equation editor. Use of the calculator allows various absolute value functions to be graphed quickly and shows their characteristics in an easy-to-understand manner. The Shift/Change feature of the EL-9600/9400 allows visual understanding of how graph changes affect the form of absolute value functions.

Solving Absolute Value Equations

The absolute value of a real number x is defined by the following:

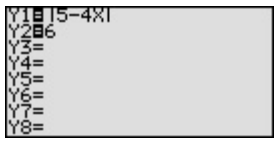
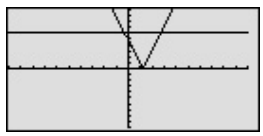
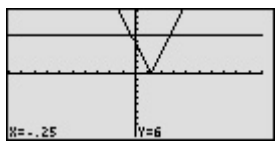
$$|x| = \begin{cases} x & \text{if } x \geq 0 \\ -x & \text{if } x \leq 0 \end{cases}$$

If n is a positive number, there are two solutions to the equation $|f(x)| = n$ because there are exactly two numbers with the absolute value equal to n: n and $-n$. The existence of two distinct solutions is clear when the equation is solved graphically.

Example

Solve an absolute value equation $|5 - 4x| = 6$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1 Enter $y = |5 - 4x|$ for Y1. Enter $y = 6$ for Y2. Y= MATH B* 1* 5 — 4 X/θ/T/n ENTER* 6		
2 View the graph. GRAPH		There are two points of intersection of the absolute value graph and the horizontal line $y = 6$.
3 Find the points of intersection of the two graphs and solve. 2nd F CALC 2* 2nd F CALC 2*		The solution to the equation $|5 - 4x| = 6$ consists of the two values -0.25 and 2.75. Note that although it is not as intuitively obvious, the solution could also be obtained by finding the x-intercepts of the function $y = |5x - 4| - 6$.

The EL-9600/9400 shows absolute values with | | just as written on paper by using the Equation editor. The graphing feature of the calculator shows the solution of the absolute value function visually.

Solving Absolute Value Inequalities

To solve an inequality means to find all values that make the inequality true. Absolute value inequalities are of the form $|f(x)| < k$, $|f(x)| \leq k$, $|f(x)| > k$, *or* $|f(x)| \geq k$. The graphical solution to an absolute value inequality is found using the same methods as for normal inequalities. The first method involves rewriting the inequality so that the right-hand-side of the inequality is 0 and the left-hand-side is a function of x. The second method involves graphing each side of the inequality as an individual function.

Example

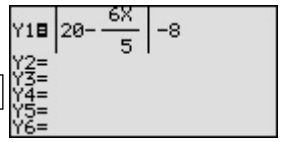
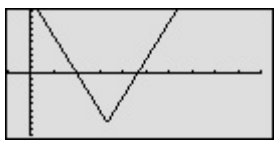
Solve absolute value inequalities in two methods.

1. Solve $|20 - \frac{6x}{5}| < 8$ by rewriting the inequality so that the right-hand side of the inequality is zero.

2. Solve $|3.5x + 4| > 10$ by shading the solution region.

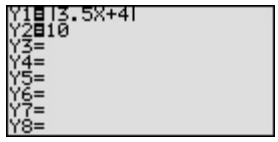
Before Start There may be differences in the results of calculations and graph plotting depending on the setting.
Return all settings to the default value or to delete all data.
Choose viewing windows "-5< x <50," and "-10< y <10" using Rapid Window feature to solve Q1.

[WINDOW] [EZ] [3] [ENTER]* [3] [ENTER]* [3] [ENTER]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Rewrite the equation.		$\|20 - \frac{6x}{5}\| < 8$ → $\|20 - \frac{6x}{5}\| - 8 < 0$.
1-2 Enter $y = \|20 - \frac{6x}{5}\| - 8$ for Y1. [Y=] [MATH] [B]* [1]* [2] [0] [—] [a/b] [6] [X/θ/T/∩] [▶]* [1] [▶] [▶]* [—] [8]		
1-3 View the graph, and find the x-intercepts. [GRAPH] [2nd F] [CALC] [5]* → $x = 10$, $y = 0$ [2nd F] [CALC] [5]* → $x = 23.33333334$ $y = 0.00000006$ (∗ Note)		The intersections with the x-axis are (10, 0) and (23.3, 0) (∗ Note: The value of y in the x-intercepts may not appear exactly as 0 as shown in the example, due to an error caused by approximate calculation.)
1-4 Solve the inequality.		Since the graph is below the x-axis for x in between the two x-intercepts, the solution is $10 < x < 23.3$.

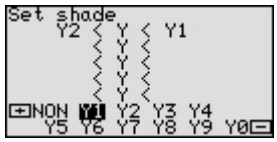
Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-1 Enter the function $y = |3.5x + 4|$ for Y1.
Enter $y = 10$ for Y2.



[Y=] [CL] [MATH] [B]* [1]*
[3] [•] [5] [X/θ/T/n] [+] [4] [ENTER]*
[1] [0]

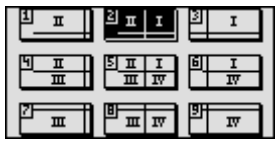
2-2 Set up shading.



[2nd F] [DRAW] [G]* [1]*
[—] [—]* [▶]* [—]*

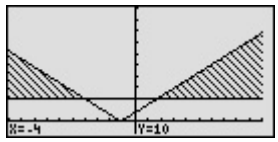
Since the inequality you are solving is Y1 > Y2, the solution is where the graph of Y2 is "on the bottom" and Y1 in "on the top."

2-3 Choose viewing windows "$-10 < x < 10$," and "$-5 < y < 50$" using Rapid Window feature and view the graph.



[WINDOW] [EZ] [2] [ENTER]* [5] [ENTER]*
[3] [ENTER]*

2-4 Find the points of intersection.
Solve the inequality.



[2nd F] [CALC] [2]* → $x = -4$, $y = 10$
[2nd F] [CALC] [2]* → $x = 1.714285714$
$y = 9.999999999$ (∗ Note)

The intersections are (-4, 10) and (1.7, 10.0). The solution is all values of x such that $x <- 4$ or $x > 1.7$.
(∗ Note: The value of y in the intersection of the two graphs may not appear exactly as 10 as shown in the example, due to an error caused by approximate calculation.)

The EL-9600/9400 shows absolute values with | | just as written on paper by using the Equation editor. Graphical solution methods not only offer instructive visualization of the solution process, but they can be applied to inequalities that are often difficult to solve algebraically. The Shade feature is useful to solve the inequality visually and the points of intersection can be obtained easily.

Evaluating Absolute Value Functions

The absolute value of a real number x is defined by the following:

$$|x| = \begin{cases} x & \text{if } x \geq 0 \\ -x & \text{if } x \leq 0 \end{cases}$$

Note that the effect of taking the absolute value of a number is to strip away the minus sign if the number is negative and to leave the number unchanged if it is nonnegative. Thus, $|x| \geq 0$ for all values of x.

Example

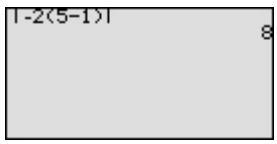
Evaluate various absolute value functions.

1. Evaluate $|-2(5-1)|$

2. Is $|-2+7| = |-2| + |7|$?
Evaluate each side of the equation to check your answer.
Is $|x + y| = |x| + |y|$ for all real numbers x and y?
If not, when will $|x + y| = |x| + |y|$?

3. Is $\left|\frac{6-9}{1+3}\right| = \frac{|6-9|}{|1+3|}$?
Evaluate each side of the equation to check your answer. Investigate with more examples, and decide if you think $|x / y| = |x| / |y|$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

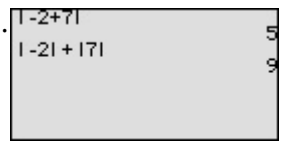
Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Access the home or computation screen. 		
1-2 Enter $y = |-2(5-1)|$ and evaluate. MATH B* 1* (-) 2 (5 — 1) ENTER		The solution is ±8.

2-1 Evaluate $|-2 + 7|$. Evaluate $|-2| + |7|$.

CL

MATH 1* (-) 2 + 7 ENTER

MATH 1* (-) 2 ▶ + MATH 1* 7 ENTER



$|-2 + 7| = 5$, $|-2| + |7| = 9$
$\rightarrow |-2 + 7| \neq |-2| + |7|$.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-2 Is $|x + y| = |x| + |y|$? Think about this problem according to the cases when x or y are positive or negative.

If $x \geq 0$ and $y \geq 0$
[e.g.; $(x, y) = (2,7)$]

$|x + y| = |2 + 7| = 9$
$|x| + |y| = |2| + |7| = 9$
$\rightarrow |x + y| = |x| + |y|$.

If $x \leq 0$ and $y \geq 0$
[e.g.; $(x, y) = (-2, 7)$]

$|x + y| = |-2 + 7| = 5$
$|x| + |y| = |-2| + |7| = 9$
$\rightarrow |x + y| \neq |x| + |y|$.

If $x \geq 0$ and $y \leq 0$
[e.g.; $(x, y) = (2, -7)$]

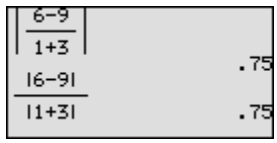
$|x + y| = |2-7| = 5$
$|x| + |y| = |2| + |-7| = 9$
$\rightarrow |x + y| \neq |x| + |y|$.

If $x \leq 0$ and $y \leq 0$
[e.g.; $(x, y) = (-2, -7)$]

$|x + y| = |-2-7| = 9$
$|x| + |y| = |-2| + |-7| = 9$
$\rightarrow |x + y| = |x| + |y|$.

Therefore $|x + y| = |x| + |y|$ when $x \geq 0$ and $y \geq 0$, and when $x \leq 0$ and $y \leq 0$.

3-1 Evaluate $\left|\frac{6-9}{1+3}\right|$. Evaluate $\frac{|6-9|}{|1+3|}$.



$\left|\frac{6-9}{1+3}\right| = 0.75$, $\frac{|6-9|}{|1+3|} = 0.75$
$\rightarrow \left|\frac{6-9}{1+3}\right| = \frac{|6-9|}{|1+3|}$

CL MATH 1 ▶ a/b 6 — 9
▶ 1 + 3 ENTER
MATH 1 6 — 9 ▶ a/b
MATH 1 1 + 3 ENTER

3-2 Is $|x / y| = |x| / |y|$?
Think about this problem according to the cases when x or y are positive or negative.

If $x \geq 0$ and $y \geq 0$
[e.g.; $(x, y) = (2,7)$]

$|x / y| = |2/7| = 2/7$
$|x| / |y| = |2| / |7| = 2/7$
$\rightarrow |x / y| = |x| / |y|$

If $x \leq 0$ and $y \geq 0$
[e.g.; $(x, y) = (-2, 7)$]

$|x / y| = |(-2)/7| = 2/7$
$|x| / |y| = |-2| / |7| = 2/7$
$\rightarrow |x / y| = |x| / |y|$

If $x \geq 0$ and $y \leq 0$
[e.g.; $(x, y) = (2, -7)$]

$|x / y| = |2/(-7)| = 2/7$
$|x| / |y| = |2| / |-7| = 2/7$
$\rightarrow |x / y| = |x| / |y|$

If $x \leq 0$ and $y \leq 0$
[e.g.; $(x, y) = (-2, -7)$]

$|x / y| = |(-2)/-7| = 2/7$
$|x| / |y| = |-2| / |-7| = 2/7$
$\rightarrow |x / y| = |x| / |y|$

The statement is true for all $y \neq 0$.

The EL-9600/9400 shows absolute values with | | just as written on paper by using the Equation editor. The nature of arithmetic of the absolute value can be learned through arithmetical operations of absolute value functions.

Graphing Rational Functions

A rational function $f(x)$ is defined as the quotient $\frac{p(x)}{q(x)}$ where $p(x)$ and $q(x)$ are two polynomial functions such that $q(x) \neq 0$. The domain of any rational function consists of all values of x such that the denominator $q(x)$ is not zero.

A rational function consists of branches separated by vertical asymptotes, and the values of x that make the denominator $q(x) = 0$ but do not make the numerator $p(x) = 0$ are where the vertical asymptotes occur. It also has horizontal asymptotes, lines of the form $y = k$ (k, a constant) such that the function gets arbitrarily close to, but does not cross, the horizontal asymptote when $|x|$ is large.

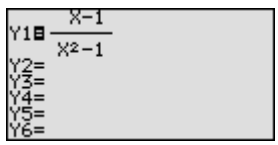
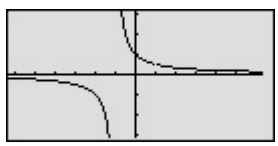
The x intercepts of a rational function $f(x)$, if there are any, occur at the x-values that make the numerator $p(x)$, but not the denominator $q(x)$, zero. The y-intercept occurs at $f(0)$.

Example

Graph the rational function and check several points as indicated below.

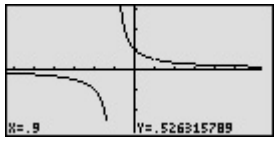
1. Graph $f(x) = \frac{x-1}{x^2-1}$.
2. Find the domain of $f(x)$, and the vertical asymptote of $f(x)$.
3. Find the x- and y-intercepts of $f(x)$.
4. Estimate the horizontal asymptote of $f(x)$.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting.
Return all settings to the default value or to delete all data.
Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [ALPHA] [▼]*) [7]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1-1 Enter $y = \frac{x-1}{x^2-1}$ for Y1. [Y=] [a/b] [X/θ/T/∩] [—] [1] [▼]* [X/θ/T/∩] [x^2] [—] [1]		
1-2 View the graph. [GRAPH]		The function consists of two branches separated by the vertical asymptote.

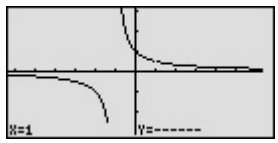
Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2 Find the domain and the vertical asymptote of $f(x)$, tracing the graph to find the hole at $x = 1$.

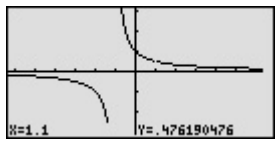


Since $f(x)$ can be written as $\frac{x - 1}{(x + 1)(x - 1)}$, the domain consists of all real numbers x such that $x \neq 1$ and $x \neq -1$. There is no vertical asymptote where $x = 1$ since this value of x also makes the numerator zero. Next to the coordinates $x = 0.9$, $y = 0.52$, see that the calculator does not display a value for y at $x = 1$ since 1 is not in the domain of this rational function.

TRACE ▶ (repeatedly)

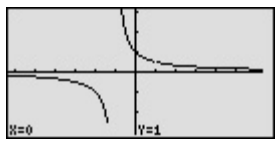


▶



3 Find the x- and y-intercepts of $f(x)$.

2nd F CALC 6*



The y-intercept is at (0 ,1). Notice that there are no x-intercepts for the graph of $f(x)$.

4 Estimate the horizontal asymptote of $f(x)$.

The line $y = 0$ is very likely a horizontal asymptote of $f(x)$.

The graphing feature of the EL-9600/9400 can create the branches of rational function separated by vertical asymptote. The calculator allows the points of intersection to be obtained easily.

SHARP

Solving Rational Function Inequalities

A rational function $f(x)$ is defined as the quotient $\frac{p(x)}{q(x)}$ where $p(x)$ and $q(x)$ are two polynomial function such that $q(x) \neq 0$. The solutions to a rational function inequality can be obtained graphically using the same method as for normal inequalities. You can find the solutions by graphing each side of the inequalities as an individual function.

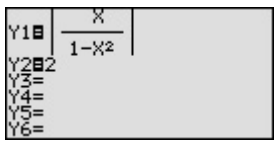
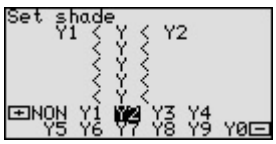
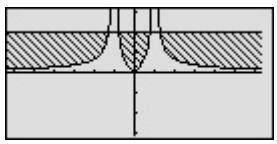
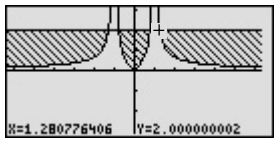
Example

Solve a rational inequality.

Solve $\left|\frac{x}{1-x^2}\right| \leq 2$ by graphing each side of the inequality as an individual function.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [ALPHA] [▼]*) [7]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1 Enter $y = \left\|\frac{x}{1-x^2}\right\|$ for Y1. Enter $y = 2$ for Y2. [Y=] [MATH] [B]* [1]* [a/b] [X/θ/T/∩] [▼]* [1] [—] [X/θ/T/∩] [x^2] [ENTER]* [2]		
2 Set up the shading. [2nd F] [DRAW] [G]* [1]* [—] [▶]* [—] [—]*		Since Y1 is the value "on the bottom" (the smaller of the two) and Y2 is the function "on the top" (the larger of the two), Y1 < Y < Y2.
3 View the graph. [GRAPH]		
4 Find the intersections, and solve the inequality. [2nd F] [CALC] [2]* Do this four times		The intersections are when x = -1.3, -0.8, 0.8, and 1.3. The solution is all values of x such that $x \leq -1.3$ or $-0.8 \leq x \leq 0.8$ or $x \geq 1.3$.

The EL-9600/9400 allows the solution region of inequalities to be indicated visually using the Shade feature. Also, the points of intersections can be obtained easily.

Graphing Parabolas

The graphs of quadratic equations ($y = ax^2 + bx + c$) are called parabolas. Sometimes the quadrafic equation takes on the form of $x = ay^2 + by + c$.
There is a problem entering this equation in the calculator graphing list for two reasons:
a) it is not a function, and only functions can be entered in the Y= list locations,
b) the functions entered in the Y= list must be in terms of x, not y.
There are, however, two methods you can use to draw the graph of a parabola.

Method 1: Consider the "top" and "bottom" halves of the parabola as two different parts of the graph because each individually is a function. Solve the equation of the parabola for y and enter the two parts (that individually are functions) in two locations of the Y= list.

Method 2: Choose the parametric graphing mode of the calculator and enter the parametric equations of the parabola. It is not necessary to algebraically solve the equation for y. Parametric representations are equation pairs $x = F(t)$, $y = F(t)$ that have x and y each expressed in terms of a third parameter, t.

Example

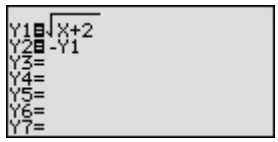
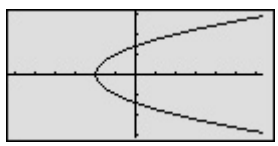
Graph a parabola using two methods.

1. Graph the parabola $x = y^2 - 2$ in rectangular mode.

2. Graph the parabola $x = y^2 - 2$ in parametric mode.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: ZOOM A* (ENTER ALPHA ▼*) 7*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Solve the equation for y.		$x = y^2 - 2$ $x + 2 = y^2$ $y = \pm\sqrt{x + 2}$
1-2 Enter $y = \sqrt{x+2}$ for Y1 and enter y = -Y1 for Y2. Y= 2nd F √ X/θ/T/n + 2 ENTER* (-) VARS A* ENTER 1*		
1-3 View the graph. GRAPH		The graph of the equation $y = \sqrt{x+2}$ is the "top half" of the parabola and the graph of the equation $y = -\sqrt{x + 2}$ gives the "bottom half."

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-1 Change to parametric mode.

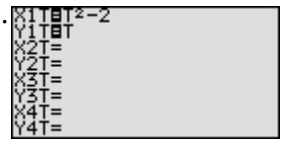
2nd F SET UP E*

2*

2-2 Rewrite $x = y^2 - 2$ in parametric form. Enter X1T = T^2 -2 and Y1T = T.

Y= X/θ/T/n x^2 — 2 ENTER*

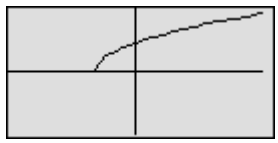
X/θ/T/n



Let y = T and substitute in $x = y^2 - 2$, to obtain $x = T^2 - 2$.

2-3 View the graph. Consider why only half of the parabola is drawn. (To understand this, use Trace feature.)

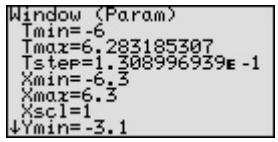
GRAPH (TRACE ▶)



The graph starts at T =0 and increases. Since the window setting is T ≥ 0, the region T < 0 is not drawn in the graph.

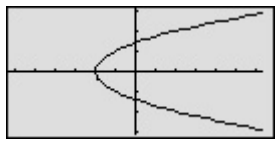
2-4 Set Tmin to -6.

WINDOW (-) 6 ENTER*



2-5 View the complete parabola.

GRAPH



The calculator provides two methods for graphing parabolas both of which are easy to perform.

Graphing Circles

The standard equation of a circle of radius r that is centered at a point (h, k) is $(x - h)^2 + (y - k)^2 = r^2$. In order to put an equation in standard form so that you can graph in rectangular mode, it is necessary to solve the equation for y. You therefore need to use the process of completing the square.

Example

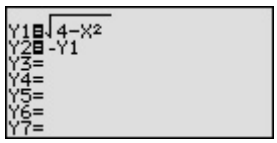
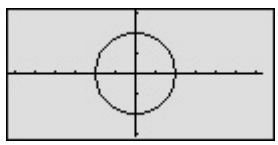
Graph the circles in rectangular mode. Solve the equation for y to put it in the standard form.

1. Graph $x^2 + y^2 = 4$.

2. Graph $x^2 - 2x + y^2 + 4y = 2$.

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: ZOOM A* (ENTER ALPHA ▼*) 7*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	Display (When using EL-9600)	Notes
1-1 Solve the equation for y. Enter $y = \sqrt{4 - x^2}$ for Y1 (the top half). Enter $y = -\sqrt{4 - x^2}$ for Y2. Y= 2nd F √ 4 — X/θ/T/n x^2 ENTER* (-) VARS A* ENTER 1*		$y^2 = 4 - x^2$ $y = \pm\sqrt{4 - x^2}$
1-2 View the graph. GRAPH		This is a circle of radius r, centered at the origin.

2-1 Solve the equation for y, completing the square.

$x^2 - 2x + y^2 + 4y = 2$	Place all variable terms on the left and the constant term on the right-hand side of the equation.
$x^2 - 2x + y^2 + 4y + 4 = 2 + 4$	Complete the square on the y-term.
$x^2 - 2x + (y+2)^2 = 6$	Express the terms in y as a perfect square.
$(y+2)^2 = 6 - x^2 + 2x$	Leave only the term involving y on the left hand side.
$y+2 = \pm\sqrt{6-x^2+2x}$	Take the square root of both sides.
$y = \pm\sqrt{6-x^2+2x} - 2$	Solve for y.

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

2-2 Enter $y = \sqrt{6 - x^2 + 2x}$ for Y1, y = Y1 - 2 for Y2, and y = -Y1 -2 for Y3.

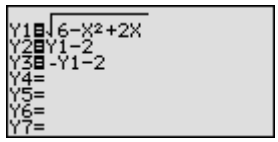
[Y=] [CL] [2nd F] [$\sqrt{\ }$] [6] [—] [X/θ/T/∩]

[x^2] [+] [2] [X/θ/T/∩] [ENTER]* [CL]

[VARS] [A]* [ENTER] [1]* [—]

[2] [ENTER]*

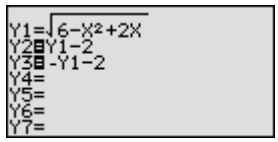
[(-)] [VARS] [ENTER] [1]* [—] [2]



Notice that if you enter $y = \sqrt{6 - x^2 + 2x} - 2$ for Y1 and y = - Y1 for Y2, you will not get the graph of a circle because the "±" does not go with the "-2".

2-3 "Turn off" Y1 so that it will not graph.

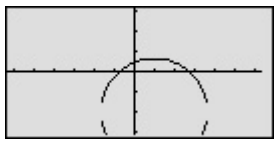
[▲] [▲] [◀]* [ENTER]*



Notice that "=" for Y1 is no longer darkened. You now have the top portion and the bottom portion of the circle in Y2 and Y3.

2-4 View the graph.

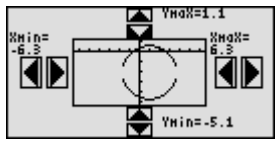
[GRAPH]



2-5 Adjust the screen to see the bottom part of the circle using the Rapid feature.

[EZ] [▼] [▼] [▼]* [ENTER]*

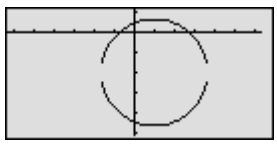
[ENTER]* [▲] [▲]* [ENTER]* [ENTER]*



Wait until the graph is displayed after each operation. (It takes few seconds to graph)

2-6 View the graph in the new window.

[GRAPH]



Graphing circles can be performed easily on the calculator display. Also, the Rapid Zoom feature of the EL-9600/9400 allows shifting and adjusting display area (window) of a graph easily.

Graphing Ellipses

The standard equation for an ellipse whose center is at the point (h, k) with major and minor axes of length a and b is $\frac{(x - h)^2}{a^2} + \frac{(y - k)^2}{b^2} = 1$.

There is a problem entering this equation in the calculator graphing list for two reasons:

a) it is not a function, and only functions can be entered in the Y = list locations.

b) the functions entered in the Y = list locations must be in terms of x, not y.

To draw a graph of an ellipse, consider the "top" and "bottom" halves of the ellipse as two different parts of the graph because each individual is a function. Solve the equation of the ellipse for y and enter the two parts in two locations of the Y = list.

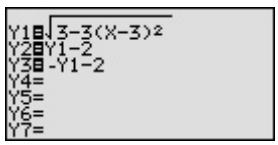
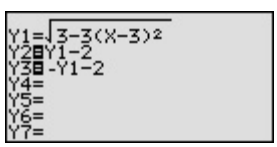
Example

Graph an ellipse in rectangular mode. Solve the equation for y to put it in the standard form.

Graph the ellipse $3(x - 3)^2 + (y + 2)^2 = 3$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [ALPHA] [▼]*) [7]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
1 Solve the equation for y, completing the square.		$3(x - 3)^2 + (y + 2)^2 = 3$ $(y + 2)^2 = 3 - 3(x - 3)^2$ $y^2 + 2 = \pm\sqrt{3 - 3(x - 3)^2}$ $y = \pm\sqrt{3 - 3(x - 3)^2} - 2$
Enter $Y1 = \sqrt{3 - 3(x - 3)^2}$ $Y2 = Y1 - 2$ $Y3 = -Y1 - 2$		
[Y=] [2nd F] [√‾] [3] [—] [3] [(]		
[X/θ/T/Π] [—] [3] [)] [x^2] [ENTER]*		
[VARS] [A]* [ENTER] [1]* [—]		
[2] [ENTER]* [(-)] [VARS] [ENTER]		
[1] [—] [2]		
2 Turn off Y1 so that it will not graph.		
[▲] [▲] [◀]* [ENTER]*		

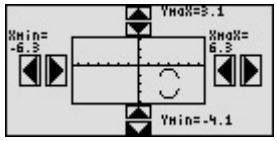
Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

3 View the graph.

GRAPH

4 Adjust the screen to see the bottom part of the ellipse using the Rapid Zoom feature.

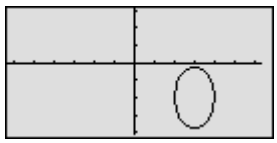
EZ ▼ ▼ ▼ * ENTER *



Wait until the graph is displayed after each operation. (It takes few seconds to graph)

5 View the graph in the new window.

GRAPH



Graphing ellipse can be performed easily on the calculator display. In addition to the Zoom-in/Zoom-out features, the EL-9600/9400 have the Rapid Zoom feature to adjust the display easily.

Graphing Hyperbolas

The standard equation for a hyperbola can take one of two forms:

$\frac{(x-h)^2}{a^2} - \frac{(y-k)^2}{b^2} = 1$ with vertices at $(h \pm a, k)$ or

$\frac{(x-k)^2}{b^2} - \frac{(y-h)^2}{a^2} = 1$ with vertices at $(h, k \pm b)$.

There is a problem entering this equation in the calculator graphing list for two reasons:

a) it is not a function, and only functions can be entered in the Y= list locations.

b) the functions entered in the Y= list locations must be in terms of x, not y.

To draw a graph of a hyperbola, consider the "top" and "bottom" halves of the hyperbola as two different parts of the graph because each individual is a function. Solve the equation of the hyperbola for y and enter the two parts in two locations of the Y= list.

Example

Graph a hyperbola in rectangular mode. Solve the equation for y to put it in the standard form.

Graph the hyperbola $x^2 + 2x - y^2 - 6y + 3 = 0$

Before Start There may be differences in the results of calculations and graph plotting depending on the setting. Return all settings to the default value or to delete all data.

Set the zoom to the decimal window: [ZOOM] [A]* ([ENTER] [ALPHA] [▼]*) [7]*

Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***

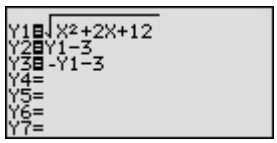
1 Solve the equation for y completing the square.

Enter

$Y1 = \sqrt{x^2 + 2x + 12}$

$Y2 = Y1 - 3$

$Y3 = -Y1 - 3$



[Y=] [2nd F] [√‾] [X/θ/T/n] [x^2] [+] [2]

[X/θ/T/n] [+] [1] [2] [ENTER]*

[VARS] [A]* [ENTER] [1]* [—] [3] [ENTER]*

[(-)] [VARS] [A]* [ENTER] [1]* [—] [3]

$x^2 + 2x - y^2 - 6y = -3$

$x^2 + 2x - (y^2 + 6y + 9) = -3 - 9$

$x^2 + 2x - (y + 3)^2 = -12$

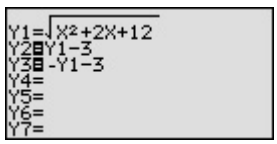
$(y + 3)^2 = x^2 + 2x + 12$

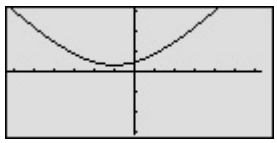
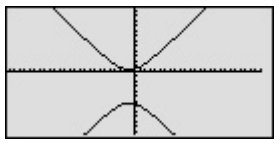
$y + 3 = \pm\sqrt{x^2 + 2x + 12}$

$y = \pm\sqrt{x^2 + 2x + 12} - 3$

2 Turn off Y1 so that it will not graph.

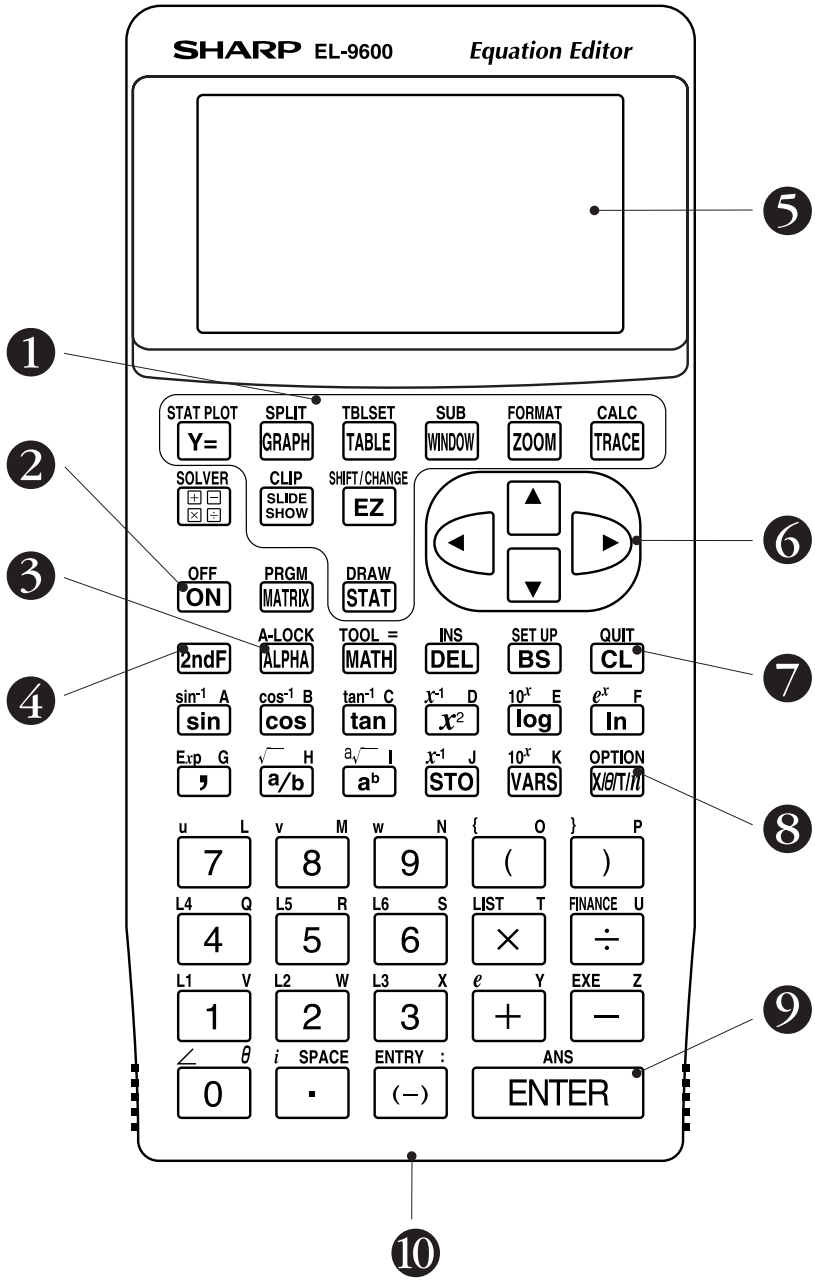
[▲] [▲] [◀]* [ENTER]*



Step & Key Operation (When using EL-9600) *Use either pen touch or cursor to operate.	***Display*** (When using EL-9600)	***Notes***
3 View the graph. GRAPH		
4 Zoom out the screen. ZOOM A* 4*		

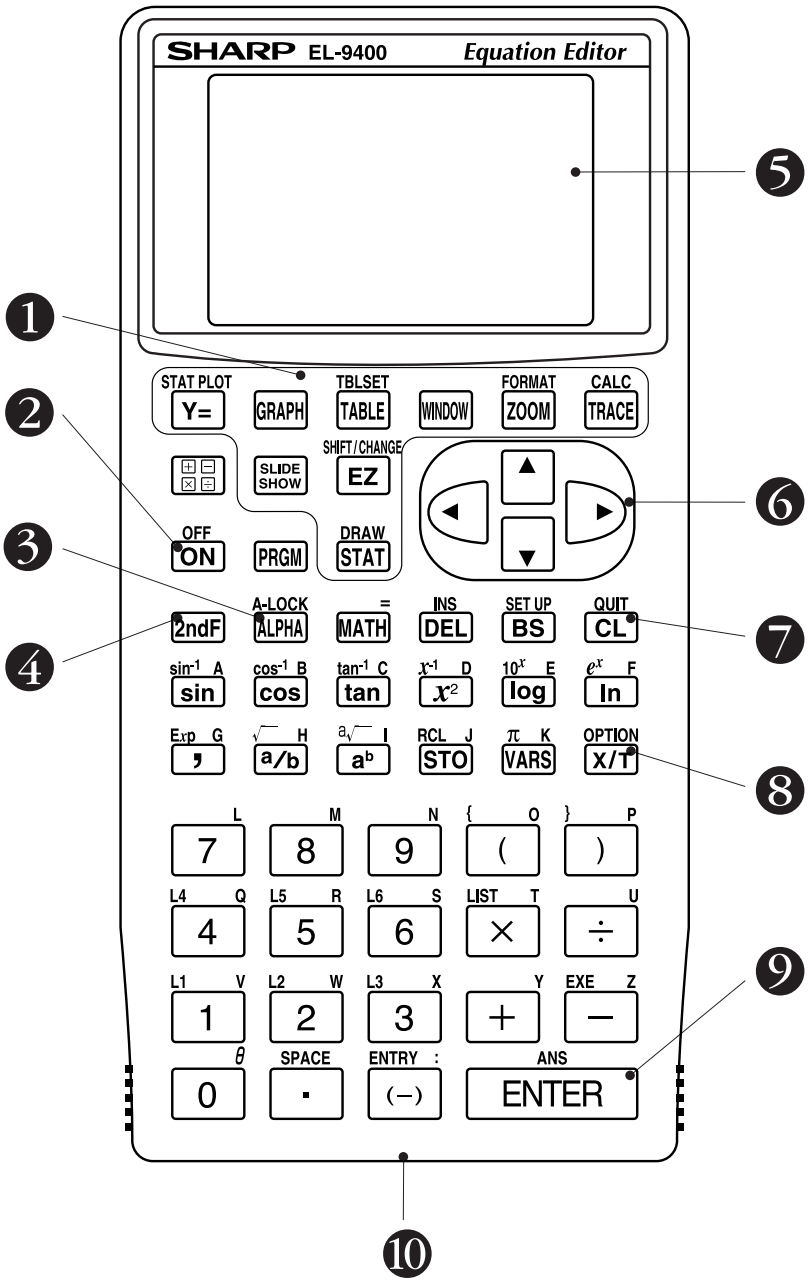
Graphing hyperbolas can be performed easily on the calculator display. In addition to the Zoom-in/Zoom-out features, the EL-9600/9400 have the Rapid Zoom feature to adjust the display easily. (See the section “Graphing Ellipses (No. 10-3)” about how to use the Rapid Zoom feature.)

Key pad for the SHARP EL-9600 Calculator



1. Graphing keys
2. Power supply ON/OFF key
3. Alphabet specification key
4. Secondary function specification key
5. Display screen
6. Cursor movement keys
7. Clear/Quit key
8. Variable enter key
9. Calculation execute key
10. Communication port for peripheral devices

Key pad for the SHARP EL-9400 Calculator



❶ Graphing keys
❷ Power supply ON/OFF key
❸ Alphabet specification key
❹ Secondary function specification key
❺ Display screen
❻ Cursor movement keys
❼ Clear/Quit key
❽ Variable enter key
❾ Calculation execute key
❿ Communication port for peripheral devices

SHARP

Use this form to send us your contribution

Dear Sir/Madam

We would like to take this opportunity to invite you to create a mathematical problem which can be solved with the SHARP graphing calculator EL-9600/9400. For this purpose, we would be grateful if you would complete the form below and return it to us by fax or mail, specifying which calculator you are writing problems for, the EL-9600 or 9400.

If your contribution is chosen, your name will be included in the next edition of The EL-9600/9400 Graphing Calculator Handbook. We regret that we are unable to return contributions.

We thank you for your cooperation in this project.

Name: (☐ Mr. ☐ Ms.) _____

School/College/Univ.: _____

Address: _____

_____ Post Code: _____ Country: _____

Phone: _____ Fax: _____

E-mail: _____

* You are making this sheet for the (☐ EL-9600, ☐ EL-9400).

SUBJECT : Write a title or the subject you are writing about.

. . . . . .

INTRODUCTION : Write an explanation about the subject.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

EXAMPLE : Write example problems.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

BEFORE START : Write any conditions to be set up before solving the problems.

STEP

NOTES

SHARP
SHARP CORPORATION Osaka, Japan
Fax:

SHARP

SHARP CORPORATION OSAKA,JAPAN

FAX:06-628-1653

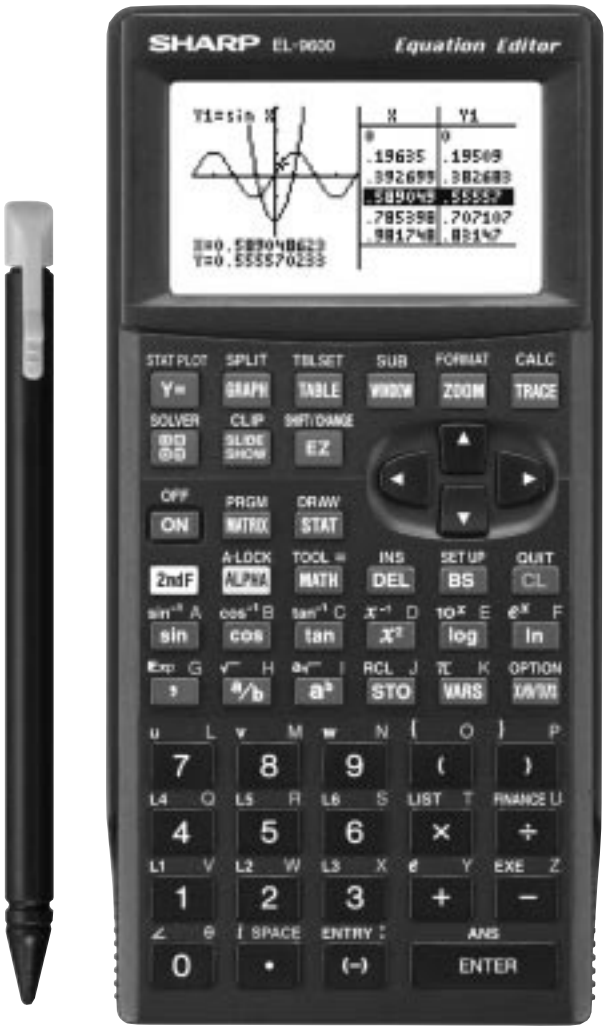
SHARP

Graphing Calculator

EL-9600/9400

Handbook Vol. 2

Programmes



EL-9600

EL-9400

Read this first

This handbook was produced for practical application of the SHARP EL-9600 and 9400 Graphing Calculator. Both calculators include a highly convenient programming function, which enables automatic processing of both simple and complex calculations any number of times.

We would like to express our deepest gratitude to all the teachers whose cooperation we received in editing this book. In order to produce a handbook which is more replete and useful to everyone, we would welcome any comments or ideas on excercises. If you wish to contribute to future editions, **use the attached blank sheet or contact us by e-mail : osksp@hsa.osa.sharp.co.jp (for Windows 95)** or **oskspm@hsb.osa.sharp.co.jp (for Macintosh)**. When sending the data by e-mail, please include relevant information such as the explanation of the programme, parameters used in the programme and the listing of the programme. Please note that the programmes you send us may be opened to the public at this home page site or in other Sharp publications.

Note: Certain problems can not be solved with the EL-9400 as indicated in contents.

1. Entering and Editing a Programme:

Programmes can be entered and edited either by pressing the calculator keys or by downloading from a PC. To download programmes from a PC, you will need the CE-LK1 PC link software (sold separately).

A. Using calculator keys

- Creating a new programme:
  1. Press 2nd F PRGM to display the programme menu.
  2. Press C ENTER to select the new programme menu. (See right)
  3. Enter the program title, then press ENTER.
  4. Enter the programme.
  5. Press 2nd F QUIT to finish programming.

- Editing a programme:
  1. Press 2nd F PRGM to display the programme menu.
  2. Press B and choose the number of the programme you wish to edit.
  3. Press 2nd F QUIT to finish editing.

(See right)

B. Downloading from PC

- Creating a new programme:
  1. Using the CE-LK 1, select the **Model Type** from the **Tools** menu and click on the same model as your calculator.
  2. Select **New** from the **File** menu.
  3. Enter a programme name in **Title:**.
  4. Enter a program. (For details on entering a programme, refer to the operation manual.) (See right)
- Programmes can also be downloaded from Sharp's website at http://www.sharp.co.jp/sc/excite/calculator/text/class96.htm instead of creating a new programme.

SHARP

- Sending programmes from a PC:
  1. Using the CE-LK1, select the **Communication Port** from the **Link** menu and click on the port to be used.
  2. Turn off the EL-9600/9400 and connect it to the PC.
  3. Turn on the EL-9600/9400
  4. Select **Send…** from the **Link** menu of the CE-LK1 (See right)
  5. Specify the kind of drive, folder, and file, then select the file to be sent from the file list, and click on the **Select** button.
  6. Click on the **OK** button.

Note : For further details refer to the manual.

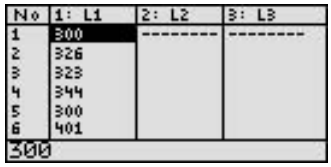
2. Executing a programme:

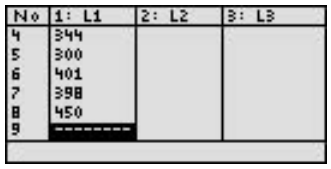
1. Press [2nd F] [PRGM] to display the execute menu.
2. Press [A] [ENTER] and choose the number of the programme you wish to execute. (See right)
3. Follow the instructions.

3. Deleting a programme:

Press [2nd F] [OPTION] [C] and then choose [5] to select the programme to be deleted.

Note: Do not try to erase a programme by resetting all memories to the initial condition as programme data to be stored will also be deleted. Also, it is advised to use the CE-LK1 PC link software to back up any programmes not to be erased.





4. Using the keys:

Press [2nd F] to use secondary functions (in yellow).
To select "$\sin^{-1}$": [2nd F] [sin] → Displayed as follows: [2nd F] [$\sin^{-1}$]

Press [ALPHA] to use the alphabet keys (in blue).
To select A: [ALPHA] [sin] → Displayed as follows: [ALPHA] [A]

Press [2nd F] [A-LOCK] to continue input of blue letters.
To input ABC: [ALPHA] [A] [ALPHA] [A] [ALPHA] [A] or [2nd F] [A-LOCK] [A] [A] [A]
(To return to the normal function, press [ALPHA] again.)

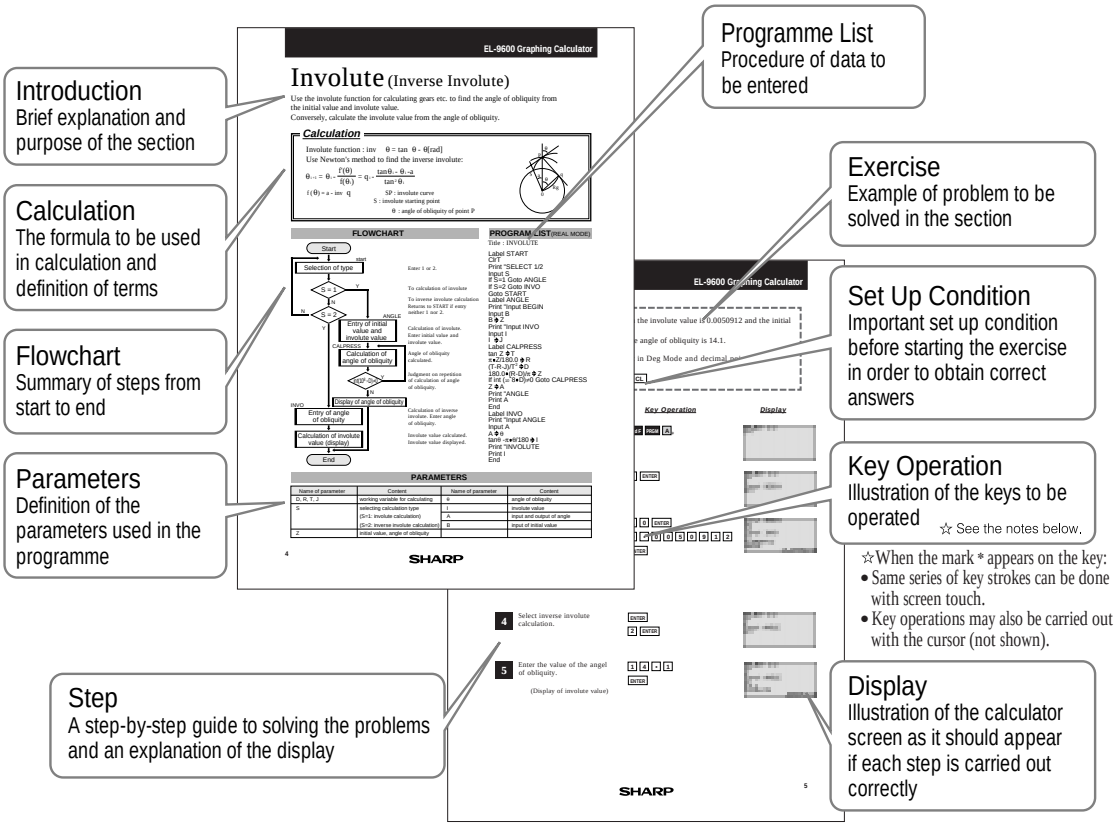
5. Troubleshooting:

Following is a list of error codes and error messages.

When errors occur, refer to pages 12, 254, or 27 of the manual.

Error code	Error message	Error content
01	Syntax	Syntax error in equation or programme
02	Calculate	Execution of a division using 0, calculation beyond calculation range, etc.
03	Nesting	Reservation of 14 or more numerical values or 32 or more functions during execution.
04	Invalid	Matrix definition error
05	Dimension	Inconsistency in the dimension of matrix during arithmetic of a matrix or dimension of list for STAT calculation.
07	Invalid DIM	Size of list and matrix input for calculation exceeds calculation range.
08	Argument	Inconsistency in argument of the structured function
09	Data Type	Invalid data type used in calculation
11	No define	Undefined list or matrix
12	Domain	Argument definition outside of domain
13	Increment	Increment error
17	Stat Med	Med-Med law (statistic) error
20	No Argument	No argument entered
21	Not pair ∫ dx	Equation definition (∫ and dx as a pair) for integral calculus does not follow syntax.
22	Not pair [ ]	Not paired with specified “[ ]”
23	Not pair ( )	Not paired with specified “( )”
24	Not pair { }	Not paired with specified “{ }”
32	No data	Data does not exist
33	Graph Type	Error in graph type setting
37	No title	No title entered
38	Too many obj	More than 30 objects selected
40	Lbl duplicate	Same label name is used more than once within a programme
41	Lbl undefined	Label is not defined for Goto or Gosub
42	Lbl over	More than 50 labels are used within a programme
43	Gosub stack	Nesting of more than 10 subroutine stacks
44	Line too long	One line of programme exceeds more than 160 characters
45	Can’t return	Use of return command without jumping from subroutine
46	Strage full	Attempt to create a file exceeding 99 (delete unnecessary files)
47	Coord type	Invalid coordinate system for command
90	Memory over	Over memory capacity
99	System error	User memory space cannot be secured

6. Page Layout



Note: This handbook is only an example of how to use programming function of the EL-9600. The layout may vary with each screen.

Contents

*only for EL-9600

Other books available:
Graphing Calculator EL-9600 TEACHER'S GUIDE
Graphing Calculator EL-9400 TEACHER'S GUIDE
Graphing Calculator EL-9600/9400 Handbook Vol. 1 (Algebra)

SHARP

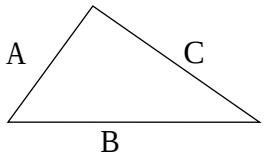
Heron's Formula

Use Heron's formula to find the area of a triangle when the sides (A,B,C) of the triangle are known.

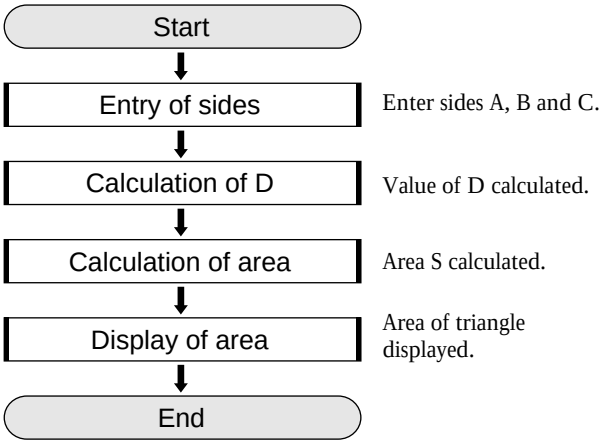
Calculation

$$S = \sqrt{D\,(D - A)\,(D - B)\,(D - C)}$$

$$D = \frac{(A + B + C)}{2}$$



FLOWCHART



PROGRAMME LIST(REAL MODE)

Title : HERON

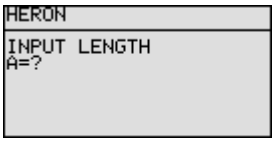
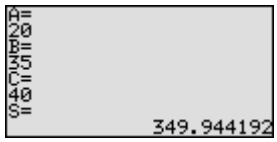
```
Print "Input LENGTH
Input A
Input B
Input C
(A+B+C)/2⇒D
√(D (D-A) (D-B) (D-C) )⇒S
Print "S =
Print S
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	value of side A	D	value of D
B	value of side B	S	area
C	value of side C		

Exercise

Find the area of a triangle when sides A, B and C are 20, 35 and 40cm respectively.

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title HERON.	2nd F PRGM A *	
2 Enter the values A, B and C.	2 0 ENTER 3 5 ENTER 4 0 ENTER	
(Display of area)		
3 The area is approximately 350cm^2.		

Calculating Tension

Use the law of sines to find the tension when a pole of weight W is suspended with two strings, and the strings are balanced with the angles from the vertical line A and B.

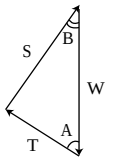
Calculation

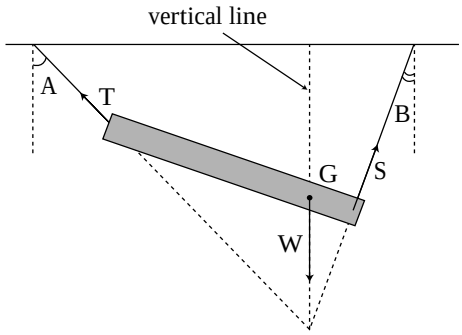
$$\frac{T}{\sin B} = \frac{S}{\sin A} = \frac{W}{\sin (A+B)}$$

$$\therefore T = W\frac{\sin B}{\sin (A+B)}$$

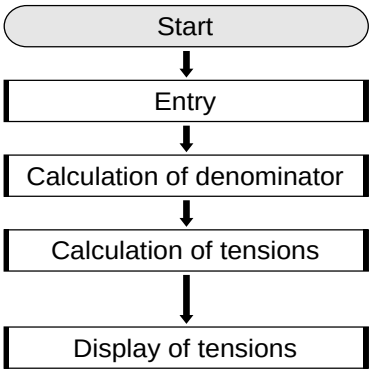
$$\therefore S = W\frac{\sin A}{\sin (A+B)}$$

T, S : tension W : weight
A, B : angles (6 sexagesimal numbers)





FLOWCHART



Enter angles and weight A, B and W.

Denominator in law of sines calculated. C= sin (A + B)

Tensions T and S calculated.
T = W ∗ sin B/C
T = W ∗ sin A/C

Tensions T and S displayed.

PROGRAMME LIST(REAL MODE)

Title : TENSION

```
Print "Input ANGLE
Input A
Input B
Print "Input WEIGHT
Input W
sin (A+B)⇒C
W∗sin B/C⇒T
W∗sin A/C⇒S
Print "TENSION
Print "T=
Print T
Print "S=
Print S
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	angle A	S	tension S
B	angle B	T	tension T
C	sin(A+B)	W	weight

SHARP

Exercise

Calculate the tension assuming weight=40kg, angle A=30˚ 15' 20", and angle B=27˚ 45' 40". Enter the angles with sexagesimal numbers.

Set up condition: decimal point digit number in TAB 3 Mode, decimal point in Fix Mode, and angle unit in Deg Mode.

[2nd F] [SET UP] [C]* [2]* [D]* [3]* [B]* [1]* [CL]

Step	***Key Operation***	***Display*** (When using EL-9600)
1 Specify the programme mode. Select the title TENSION.	[2nd F] [PRGM] [A]*	TENSION Input ANGLE A=?
2 Enter the values of angles A and B.	[3] [0] [•] [1] [5] [2] [0] [ENTER] [2] [7] [•] [4] [5] [4] [0] [ENTER]	Input ANGLE A= 30.1520 B= 27.4540 Input WEIGHT W=?
3 Enter the value of weight.	[4] [0] [ENTER]	Input WEIGHT W= 40 TENSION T= 21.840 S= 23.795
4 Tension T is 21.840kg and S is 23.795kg.		

Involute (Inverse Involute)

Use the involute function for calculating gears etc. to find the angle of obliquity from the initial value and involute value.
Conversely, calculate the involute value from the angle of obliquity.

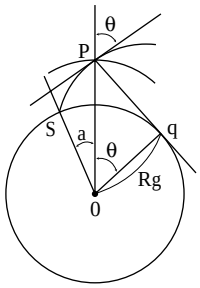
Calculation

Involute function : inv θ = tan θ - θ[rad]
Use Newton's method to find the inverse involute:

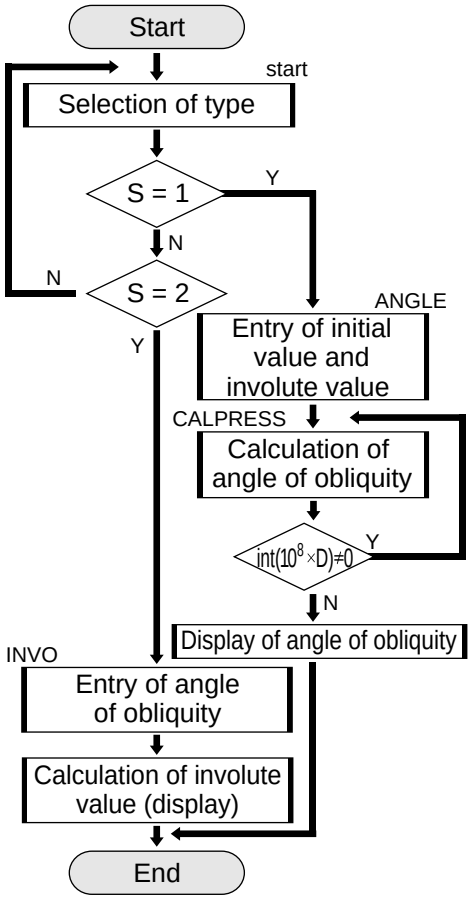
$$\theta_{i+1} = \theta_i - \frac{f'(\theta)}{f(\theta_i)} = \theta_i - \frac{\tan\theta_i - \theta_i - a}{\tan^2\theta_i}$$

$f(\theta) = a - \text{inv}\theta$

SP : involute curve
S : involute starting point
θ : angle of obliquity of point P



FLOWCHART



Enter 1 or 2.

To calculation of involute

To inverse involute calculation
Returns to START if entry neither 1 nor 2.

Calculation of involute.
Enter initial value and involute value.

Angle of obliquity calculated.

Judgment on repetition of calculation of angle of obliquity.

Calculation of inverse involute. Enter angle of obliquity.

Involute value calculated.
Involute value displayed.

PROGRAMME LIST (REAL MODE)

Title : INVOLUTE

```
Label START
ClrT
Print "SELECT 1/2
Input S
If S=1 Goto ANGLE
If S=2 Goto INVO
Goto START
Label ANGLE
Print "Input BEGIN
Input B
B⇒Z
Print "Input INVO
Input I
I ⇒J
Label CALPRESS
tan Z⇒T
π∗Z/180.0⇒R
(T-R-J)/T^2⇒D
180.0∗(R-D)/π⇒Z
If int (10^8∗D)≠0 Goto CALPRESS
Z⇒A
Print "ANGLE
Print A
End
Label INVO
Print "Input ANGLE
Input A
A⇒θ
tanθ -π∗θ/180⇒I
Print "INVOLUTE
Print I
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
D, R, T, J	working variable for calculating	θ	angle of obliquity
S	selecting calculation type	I	involute value
	(S=1: involute calculation)	A	input and output of angle
	(S=2: inverse involute calculation)	B	input of initial value
Z	initial value, angle of obliquity		

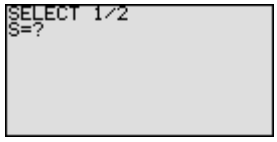
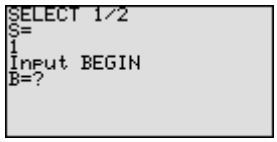
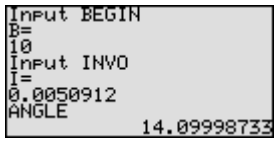
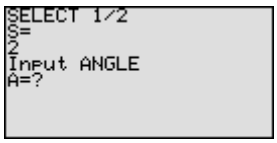
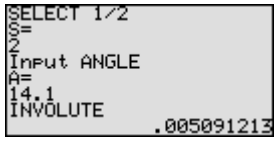
Exercise

(1) Find the angle of obliquity when the involute value is 0.0050912 and the initial value is 10.

(2) Find the involute value when the angle of obliquity is 14.1.

Set up condition: angle unit in Deg Mode and decimal point in Float Pt Mode.

[2nd F] [SET UP] [B] * [1] * [C] * [1] * [CL]

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title INVOLUTE.	[2nd F] [PRGM] [A] *	
2 Select involute calculation.	[1] [ENTER]	
3 Enter the initial value and the involute value. (Display of angle of obliquity)	[1] [0] [ENTER] [0] [•] [0] [0] [5] [0] [9] [1] [2] [ENTER]	
4 Select inverse involute calculation.	[ENTER] [2] [ENTER]	
5 Enter the value of the angle of obliquity. (Display of involute value)	[1] [4] [•] [1] [ENTER]	

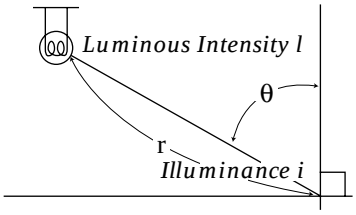
Calculating Illuminance and Luminous Intensity

Enter the luminous intensity of luminous source, distance, the angle between the perpendicular line and light ray, to find the illuminance of the illuminated side.
Conversely, find the luminous intensity of the source from the illuminance of the illuminated side.

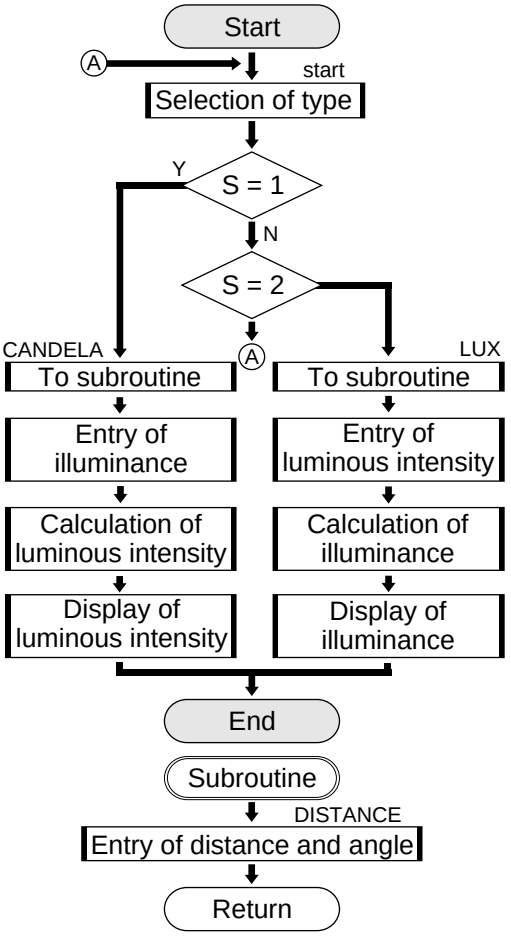
Calculation

$$i = \frac{l \cdot \cos\theta}{r^2} \qquad l = \frac{r^2 \cdot i}{\cos\theta}$$

l : luminous intensity [candela] i : illuminance [lux]
r : distance [m] θ : angle [°]



FLOWCHART



Enter 1 or 2.

To calculation of luminous intensity

To calculation of illuminance

Jumps to subroutine DISTANCE.

Enter illuminance or luminous intensity.

Illuminance or luminous intensity calculated.

Illuminance or luminous intensity displayed.

Subroutine for entry of distance and angle

Entry

Returns to calling program.

PROGRAM LIST (REAL MODE)

Title : CAND LUX

```
Label START
ClrT
Print "CANDELA=1 LUX=2
Print "SELECT 1/2
Input S
If S=1 Goto CANDELA
If S=2 Goto LUX
Goto START
Label CANDELA
Gosub DISTANCE
Print "Input LUX
Input L
L ⇒I
R²*I/cos θ⇒C
Print "CANDELA
Print C
End
Label LUX
Gosub DISTANCE
Print "Input CANDELA
Input C
C⇒K
K*cos θ /R² ⇒L
Print "LUX
Print L
End
Label DISTANCE
Print "Input DISTANCE
Input D
D⇒R
Print "Input ANGLE
Input A
A⇒θ
Return
```

PARAMETERS

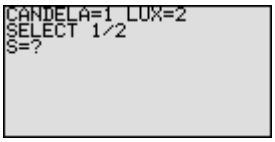
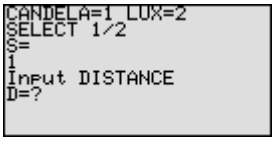
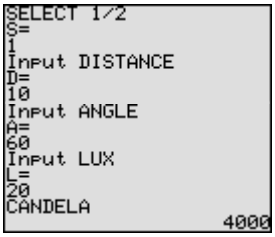
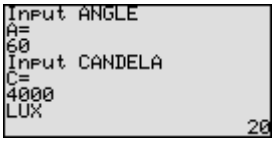
Name of parameter	Content	Name of parameter	Content
I	illuminance of luminated side	θ	angle
K	luminous intensity of luminous source	A	input of angle
R	distance	L	input and calculating luminous intensity
S	selecting calculation type (S=1: calculation of luminous intensity) (S=2: calculation of illuminance)	D	input of distance
		C	input and calculating illuminance

Exercise

(1) Find the luminous intensity of the luminous source of distance 10m, angle 60˚ and illuminance 20 lux.
(2) Find the illuminance of the illuminated side of distance 10m, angle 60˚ and luminous intensity 4000 candela.

Set up condition: angle unit in Deg Mode and decimal point in Float Pt Mode.

[2nd F] [SET UP] [B] * [1] * [C] * [1] * [CL]

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title CAND LUX.	[2nd F] [PRGM] [A] *	
2 Select calculation of luminous intensity.	[1] [ENTER]	
3 Enter the values of distance, angle, and illuminance. (Display of luminous intensity)	[1] [0] [ENTER] [6] [0] [ENTER] [2] [0] [ENTER]	
4 Select calculation of illuminance. Enter the values of distance, angle, and luminous intensity. (Display of illuminance)	[ENTER] [2] [ENTER] [1] [0] [ENTER] [6] [0] [ENTER] [4] [0] [0] [0] [ENTER]	

Calculating Simple Harmonic Oscillation

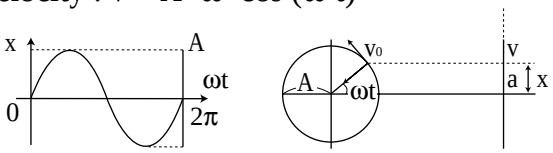
Enter period, amplitude and time to calculate displacement at specified time, acceleration, angular velocity, and velocity. Also, display the changes during the entered time period on a graph.

Calculation

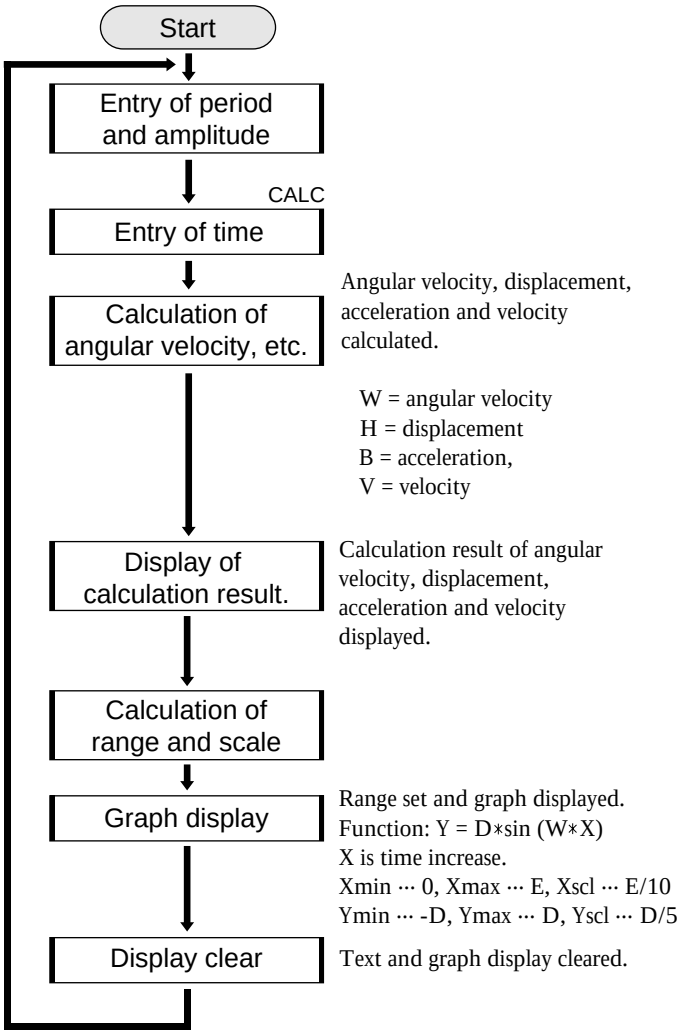
angular velocity : $\omega = \frac{2\pi}{T}$ displacement : $x = A \times \sin(\omega t)$

acceleration : $a = -\omega^2 \times x$ velocity : $v = A \times \omega \times \cos(\omega t)$

A : amplitude
t : time [sec]
T : period [sec]
ω : angular velocity [rad/sec]



FLOWCHART



PROGRAMME LIST (REAL MODE)

Title : OSCILLAT

```
Print "Input PERIOD
Input P
P⇒F
Print "Input AMPLITUDE
Input A
A⇒D
Label CALC
Print "Input TIME
Input T
T⇒E
2∗π/F⇒W
D∗sin (W∗E)⇒H
-(W²)∗H⇒B
D∗W∗cos (W∗E)⇒V
Print "ANGULAR VELOCITY
Print W
Print "MAGNITUDE
Print H
Print "ACCELERATION
Print B
Print "VELOCITY
Print V
Wait
E/10⇒X scl
D/5 ⇒Y scl
0⇒Xmin:E⇒Xmax
-D⇒Ymin:D⇒Ymax
Draw D∗sin (W∗X)
Wait
ClrT
ClrG
Goto CALC
```

PARAMETERS

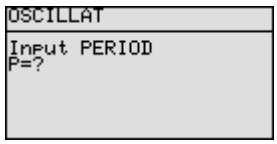
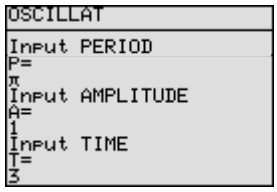
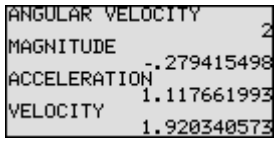
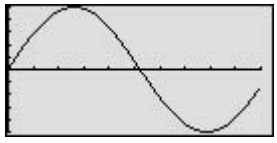
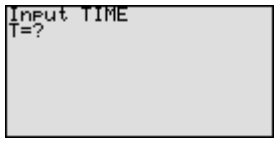
Name of parameter	Content	Name of parameter	Content
B	acceleration	A	input of amplitude
E	time	P	input of period
V	velocity	T	input of time
W	angle of velocity (ω)	D	amplitude
H	displacement	F	period
Xscl	x-axis scale	X	time increase
Yscl	y-axis scale		

Exercise

Calculate angular velocity, etc., using period π, amplitude 1 and time 3 seconds and display the changes on a graph.

Set up condition: angle unit in Rad Mode and decimal point in Float Pt Mode.

[2nd F] [SET UP] [B]* [2]* [C]* [1]* [CL]

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title OSCILLAT.	[2nd F] [PRGM] [A]*	
2 Enter the values of period, amplitude, and time.	[2nd F] [π] [ENTER] [1] [ENTER] [3]	
3 (Display of angular velocity) (Display of displacement) (Display of acceleration) (Display of velocity)	[ENTER]	
4 (Display of graph of simple harmonic oscillation)	[ENTER]	
5	[ENTER]	

Electric Power Consumed on an AC Circuit

Enter the voltage effective value, frequency and resistance value to find the power value of the circuit with resistance R. Draw a graph of the changes in power over a period of time.

Calculation

P : power consumption I : effective value of current

V : effective value of voltage

$I_0 = N \cdot \sin \omega \cdot t$ $V_0 = M \cdot \sin \omega \cdot t$ $P_0 = I_0 \cdot V_0$

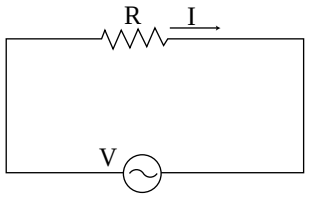
P_0 : change in amount of power with time

I_0 : change in amount of current with time

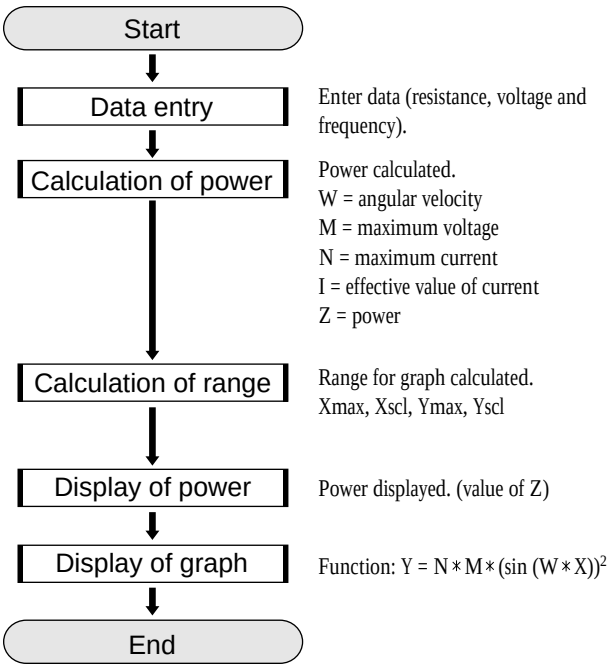
V_0: change in amount of voltage with time

N: maximum value of current M: maximum value of voltage

ω: angular velocity ($2 \pi S$) t : time S : frequency



FLOWCHART



PROGRAM LIST(REAL MODE)

Title : AC POWER

```
Print "Input RESISTANCE
Input R
Print "Input VOLTAGE
Input V
Print "Input FREQUENCY
Input F
R⇒T
V⇒D
F⇒ S
2∗π∗S ⇒W
D∗√2⇒ M
M/T⇒N
N/√2⇒I
D∗I⇒ Z
1/S ⇒ Xmax
Xmax/10⇒Xscl
N∗M⇒ Ymax
Ymax/10⇒Yscl
Print "WATT=
Print Z
Wait
0⇒Xmin
0⇒Ymin
Draw N∗M∗(sin (W∗X))2
End
```

PARAMETERS

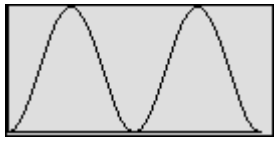
Name of parameter	Content	Name of parameter	Content
S	frequency	Xscl	scale of x-axis
I	effective value of current	Ymax	maximum value of y-axis
T	resistance value	Yscl	scale of y-axis
D	effective value of voltage	V	input of voltage
W	angular velocity	R	input of resistance value
N	maximum value of current	F	input of frequency
M	maximum value of voltage	Z	value of power
Xmax	maximum value of x-axis		

Exercise

Find the power value of an AC circuit with resistance value 150Ω, voltage effective value 100V and frequency 50Hz and display on a graph the changes in power over a period of time.

Set up condition: angle unit in Rad Mode and decimal point in Float Pt Mode.

[2nd F] [SET UP] [B]* [2]* [C]* [1]* [CL]

Step	***Key Operation***	***Display*** (When using EL-9600)
1 Specify the programme mode. Select the title AC POWER.	[2nd F] [PRGM] [A]*	AC POWER Input RESISTATCE R=?
2 Enter the resistance value, voltage effective value, and frequency. (Display of value power)	[1] [5] [0] [ENTER] [1] [0] [0] [ENTER] [5] [0] [ENTER]	Input RESISTATCE R= 150 Input VOLTAGE V= 100 Input FREQUENCY F= 50 WATT= 66.66666667
3 (Display of graph)	[ENTER]	

Angle of Vector

Use the matrix operation feature to find the angle θ which forms the standard vector and vector. The angle can be calculated at one time against the multiple vectors.

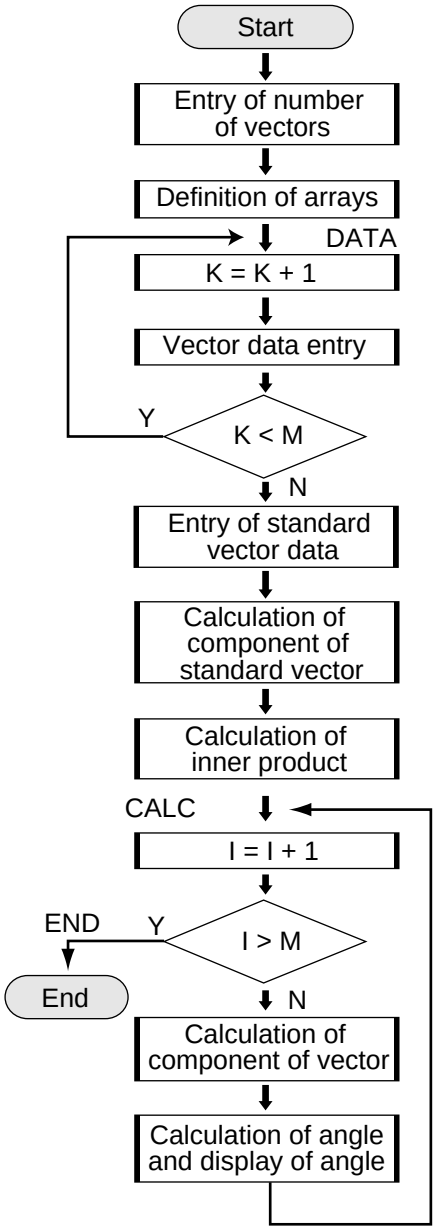
Calculation

Calculating vector inner product $\vec{a}\cdot\vec{b} = |\vec{a}||\vec{b}|\cos\theta$

Use the above expression to derive the following expression

$$\theta = \cos^{-1}\frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|}$$

FLOWCHART



Enter no. of vectors for which angles are calculated.

Arrays defined.
matA, matB, matC.

Counter for data entry

Enter x component and Y component of each vector.

Entry repeated by no. of vectors.

Enter x component and Y component of standard vector.

Length component of standard vector (scalar) calculated.

Product of matrices A and B calculated.

Counter for calculation of angle

Calculation repeated by no. of vectors.

Length component of vector (scalar) calculated.

Angle calculated and displayed.

PROGRAMME LIST(MATRIX MODE)

```
Title : VECTOR
0⇒ I
0⇒K
Print " Input NUMBER
Input N
N⇒M
{M,2}⇒dim  (mat A)
{2,1} ⇒dim  (mat B)
{M,1}⇒dim  (mat C)
Label DATA
K + 1⇒K
Print " Input VECTOR
Print K
Input X
X⇒mat  A(K,1)
Input Y
Y⇒mat  A(K,2)
If  K<M Goto DATA
Print "Input FUNDAMENTAL VECTOR
Input  X
X⇒mat   B(1,1)
Input  Y
Y⇒mat  B(2,1)
√ (mat  B(1,1)²+mat  B(2,1)²)⇒B
mat  A∗mat  B⇒mat  C
Label  CALC
I + 1⇒I
If I>M  Goto  END
√ (mat  A(I,1)²+mat  A(I,2)²)⇒A
cos⁻¹  (mat  C(I,1) / (A∗B))⇒θ
Print "ANGLE OF VECTOR
Print I
Print "θ=
Print θ
Wait
Goto CALC
Label END
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	vector scalar quantity	θ	vector angle
B	standard vector scalar quantity	K	display
I	calculating counter	N	input of number of vectors
K	input counter	mat A	vector components
M	number of vectors	mat B	standard vector components
X	input of x component	mat C	vector inner product
Y	input of y component		

Exercise

Calculate the angle formed by the following 3 vectors and standard vector (2,3).
vector 1 (5, 8)
vector 2 (7, 4)
vector 3 (9, 2)

Set up condition: angle unit in Deg mode, and decimal point in Float Pt mode.

[2nd F] [SET UP] [B]* [1]* [C]* [1]* [CL]

Step	Key Operation	Display
1 Specify the programme mode. Select the title VECTOR.	[2nd F] [PRGM] [A]*	VECTOR Input NUMBER N=?
2 Enter the number of vectors.	[3] [ENTER]	VECTOR Input NUMBER N= 3 Input VECTOR 1 X=?
3 Enter the values of vector 1.	[5] [ENTER] [8] [ENTER]	1 X= 5 Y= 8 Input VECTOR 2 X=?
4 Enter the values of vectors 2 and 3.	[7] [ENTER] [4] [ENTER] [9] [ENTER] [2] [ENTER]	3 X= 9 Y= 2 Input FUNDAMENTAL VECTOR X=?
5 Enter the value of standard vector. (Display of angle of vector 1)	[2] [ENTER] [3] [ENTER]	X= 2 Y= 3 ANGLE OF VECTOR 1 θ= 1.684684318
6 (Display of angle of vector 2)	[ENTER]	ANGLE OF VECTOR 2 θ= 26.56505118
(Display of angle of vector 3)	[ENTER]	ANGLE OF VECTOR 3 θ= 43.78112476

Linear Transformation

Use the matrix to find four types of the linear transformation of x-axis symmetric transformation, y-axis symmetric transformation, similar transformation and revolution around the origin.

Calculation

1. Symmetric transformation to x-axis (Case 1)

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

2. Symmetric transformation to y-axis (Case 2)

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

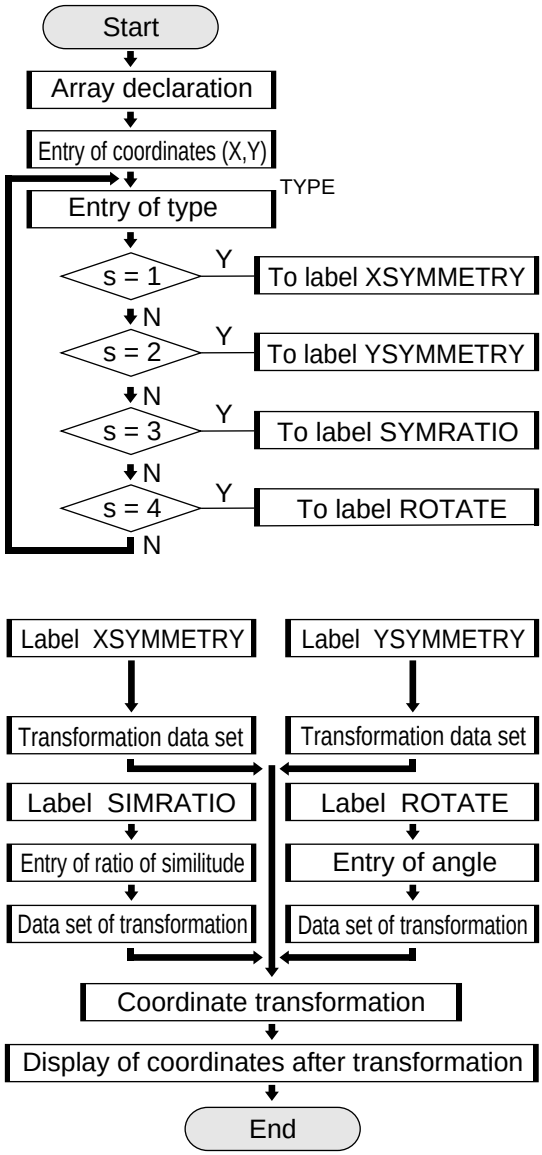
3. Similar transformation with ratio of similitude K around origin (Case 3)

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} K & 0 \\ 0 & K \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

4. Transformation revolving around only angle B at the origin (Case 4)

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} \cos B & -\sin B \\ \sin B & \cos B \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

FLOWCHART



Declare array size, etc.
matH(2,2), matD(2,1), matA(2,1)
Enter coordinates before transformation.

Type of transformation specified with no from 1 to 4.

Jumps to destination corresponding to entered number.

XSYMMETRY
Data set of x-axis symmetric transformation
matH(1,1) = 1, matH(1,2) = 0,
matH(2,1) = 0, matH(2,2) = -1

YSYMMETRY
Data set of y-axis symmetric transformation
matH(1,1) = -1, matH(1,2) = 0,
matH(2,1) = 0, matH(2,2) = 1

SIMRATIO
Data set of similar transformation
Entry of ratio of similitude (R)
matH(1,1) = K, matH(1,2) = 0,
matH(2,1) = 0, matH(2,2) = θ

Data set of transformation by revolving
Entry of angle (A)
matH(1,1) = cos B, matH(2,1) = sin B,
matH(1,2) = -sin B, matH(2,2) = cos B,

Matrix H multiplied by matrix D.

Coordinates displayed.

PROGRAMME LIST

(MATRIX MODE)

```
Title : LINE TRNS

{2, 2}⇒dim(mat H)
{2, 1}⇒dim(mat D)
{2, 1}⇒dim(mat A)
Print "Input POINT
Input X
Input Y
X⇒mat D(1, 1)
Y⇒mat D(2, 1)
Label TYPE
Print "SELECT 1/2/3/4
Input S
ClrT
If S=1 Goto XSYMMETRY
If S=2 Goto YSYMMETRY
If S=3 Goto SIMRATIO
If S=4 Goto ROTATE
GotoTYPE
Label XSYMMETRY
1⇒mat H(1, 1)
0⇒mat H(2, 1)
0⇒mat H(1, 2)
-1⇒mat H(2, 2)
Goto TRANS
Label YSYMMETRY
-1⇒mat H(1, 1)
0⇒mat H(2, 1)
0⇒mat H(1, 2)
1⇒mat H(2, 2)
Goto TRANS
Label SIMRATIO
Print "Input SIMILITUDE RATIO
Input R
R⇒K
K⇒mat H(1, 1)
0⇒mat H(2, 1)
0⇒mat H(1, 2)
θ⇒mat H(2, 2)
Goto TRANS
Label ROTATE
Print "Input ANGLE
Input A
A⇒B
cos B⇒mat H(1, 1)
sin B⇒mat H(2, 1)
-sin B⇒mat H(1, 2)
cos B⇒mat H(2, 2)
Label TRANS
mat H×mat D⇒mat A
Print "mat A(1, 1)
Print mat A(1, 1)
Print "mat A(2, 1)
Print mat A(2, 1)
End
```


SHARP

PARAMETERS

Name of parameter	Content	Name of parameter	Content
B	angle	Y	y-coordinate
K	ratio of similitude	A	input of angle
S	selecting type (S=1: case 1, S=2: case 2, S=3: case 3, S=4: case 4)	R	input of ratio of similitude
		mat A	coordinate after transformation
		mat H	transformation data
X	x-coordinate	mat D	x,y-coordinate

Exercise

1. Transform symmetrically the point (3, 5) to the x-axis.
2. Rotate the point (2, 6) at 45° around the origin.

Set up condition: angle unit in Deg Mode and decimal point in Float Pt Mode.

2nd F SET UP B * 1 * C * 1 * CL

Step	Key Operation	Display
1 Specify the programme mode. Select the title LINE TRNS.	2nd F PRGM A *	LINE TRN Input POINT X=?
2 Enter the values of the point.	3 ENTER 5 ENTER	Input POINT X= 3 Y= 5 SELECT 1/2/3/4 S=?
3 Select symmetric transformation to x-axis (case 1).	1 ENTER	mat A(1,1) 3 mat A(2,1) -5
4 Select transformation revolving around only angle B at the origin (case 4).	ENTER 2 ENTER 6 ENTER 4 ENTER	Input POINT X= 2 Y= 6 SELECT 1/2/3/4 S= 4
5 Enter the angle value.	4 5 ENTER	Input ANGLE A= 45 mat A(1,1) -2.828427125 mat A(2,1) 5.656854249

Moving Average

Plot a moving average graph which helps to understand how the results change over a specified period. The progress of sales and amounts of consumption and production can also be seen.

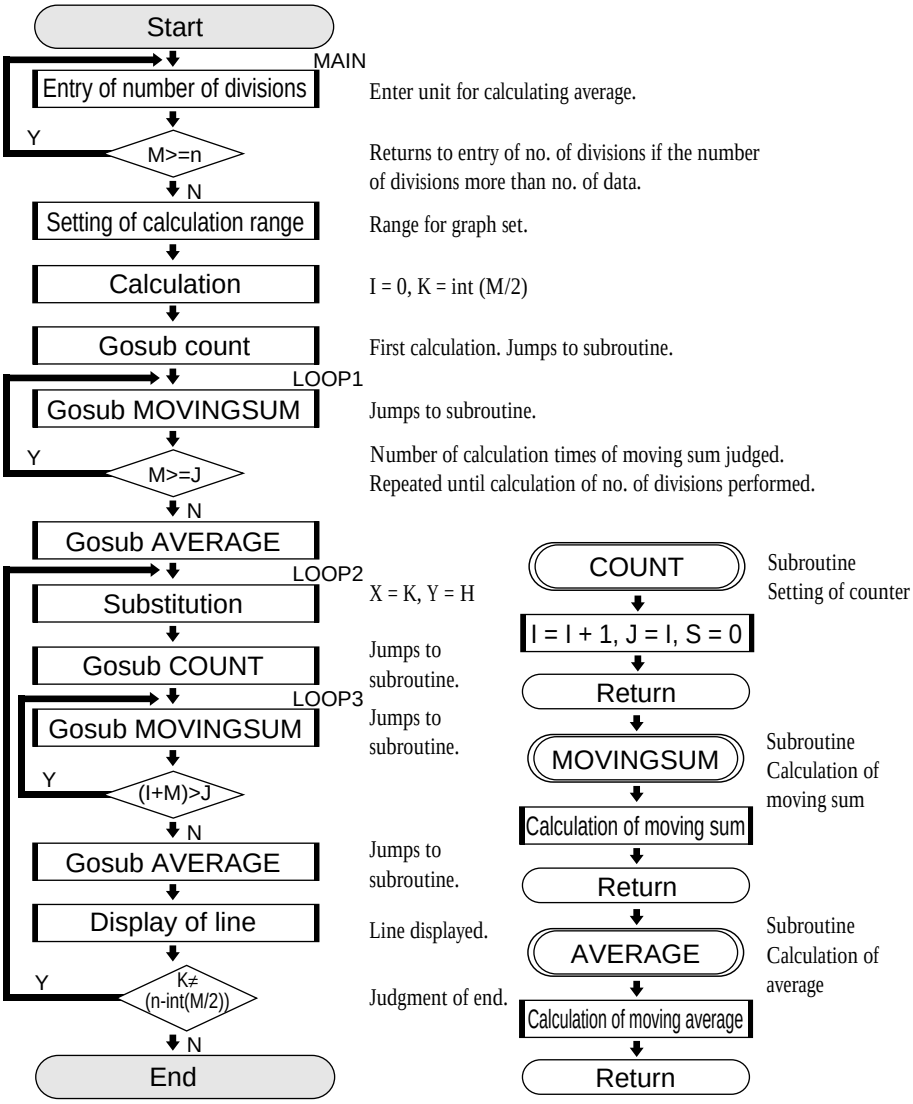
Calculation

$$H_i = \frac{X_{i-(M-1)/2} + \ldots + X_i + \ldots X_{i+(M-1)/2}}{M}$$

$$\left(I = 1 + \frac{M-1}{2}, 2 + \frac{M-1}{2}, \ldots, n + \frac{M-1}{2} \right)$$

H_i : moving average
M : number of divisions
X_i : data
n : number of data

FLOWCHART



PROGRAMME LIST

(STAT MODE)

Title : MVIN AVG

```
Label MAIN
Print "Input DIVISION
Input D
D⇒M
1_Stats L1
If M≥n Goto MAIN
Rem RANGE
(xmax-xmin)/10⇒Yscl
0⇒Xmin
n⇒Xmax
1⇒Xscl
xmin⇒Ymin
xmax⇒Ymax
0⇒I
int (M/2)⇒K
Gosub COUNT
Label LOOP1
Gosub MOVINGSUM
If M≥J Goto LOOP1
Gosub AVERAGE
Label LOOP2
K⇒X
H⇒Y
Gosub COUNT
Label LOOP3
Gosub MOVINGSUM
If (I+M)>J Goto LOOP3
Gosub AVERAGE
Line (X, Y, K, H)
If K≠(n-int (M/2))Goto LOOP2
Wait
End
Label COUNT
I+1⇒I
I⇒J
0⇒S
Return
Label MOVINGSUM
S+L1(J)⇒S
J+1⇒J
Return
Label AVERAGE
S/M⇒H
K+1⇒K
Return
```

Parameters

name of parameter	content	name of parameter	content
H	moving average	S	moving sum
I	counter	X	starting point (x)
J	counter	Y	starting point (y)
K	counter	Yscl	scale of y-axis
M	number of divisions	B	input of number of divisions

Exercise

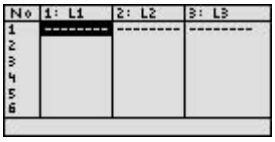
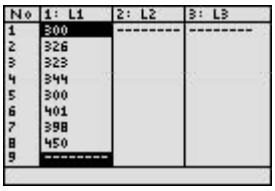
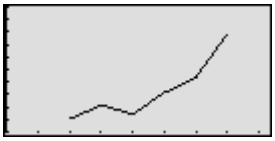
Find the moving average every three months (number of divisions: 3) from the following table of monthly sales.

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Sales[$]	300	326	323	344	300	401	398	450

On the graph, Xmax = 8, Ymin = 300, and Ymax = 450.

Set up condition: decimal point in Float Pt Mode.

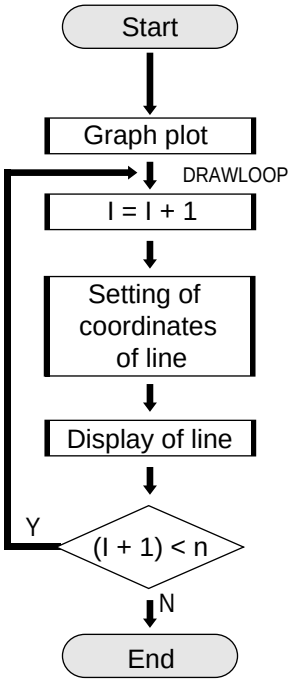
[2nd F] [SET UP] [C]* [1]* [CL]

Step	Key Operation	Display (When using EL-9600)
1 Enter statistical data into L1.	[STAT] [A]* [ENTER]	
	[3] [0] [0] [ENTER] [3] [2] [6] [ENTER] [3] [2] [3] [ENTER] [3] [4] [4] [ENTER] [3] [0] [0] [ENTER] [4] [0] [1] [ENTER] [3] [9] [8] [ENTER] [4] [5] [0] [ENTER]	
2 Specify the programme mode. Select the title MVIN AVG.	[2nd F] [PRGM] [A]*	
3 Enter the number of divisions(3).	[3] [ENTER]	

Creating a Graph of Experimental Data

Graph the results of an experiment and examine the trends.
(Example: examined data relating to water vapour pressure and temperature.)

FLOWCHART



Enter statistical data using statistics feature before executing program.

Graph plotted using automatic scaling.

Counter

Data as coordinates (starting point and finishing point).

Line drawn between set coordinates.

Whether or not lines of no. of data drawn judged. Repeated until lines drawn by the no. of data.

PROGRAMME LIST(STAT MODE)

Title : XY GRAPH

```
ClrG
Rem DRAWING SD
2 -Stats L1,L2
Rem RANGE
xmin⇒Xmin
xmax ⇒ Xmax
ymin ⇒ Ymin
ymax⇒Ymax
(Xmax-Xmin) / 10⇒Xscl
(Ymax-Ymin) / 10⇒Yscl
Rem BROKEN LINE
0⇒I
Label  DRAWLOOP
I+1⇒I
L1(I)⇒X
L2(I)⇒Y
L1(I+1)⇒Z
L2(I+1)⇒W
Line(X,Y,Z,W)
If (I+1) <n Goto DRAWLOOP
Wait
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
I	counter	Y	y of line starting point
X	x of line starting point	W	y of line finishing point
Z	x of line finishing point		

*n = number of statistical data

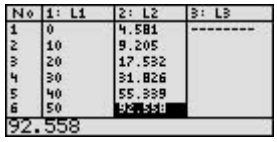
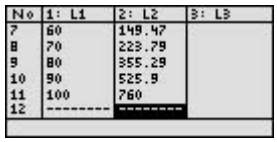
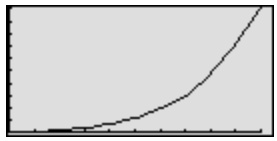
Exercise

The following table shows examined water vapour pressure. Draw a graph of this data.

Temperature [˚C]	0	10	20	30	40	50	60	70	80	90	100
Pressure [mmHg]	4.581	9.205	17.532	31.826	55.339	92.558	149.47	223.79	355.29	525.90	760.00

Set up condition: decimal point in Float Pt Mode.

2nd F SET UP C * 1 * CL

Step	Key Operation	Display (When using EL-9600)
1 Enter statistical data into L1 and L2.	STAT A * ENTER	
2	0 ENTER 1 0 … 1 0 0 ENTER (Other numbers not shown)	
3	4 • 5 8 1 ENTER … 7 6 0 ENTER	
4 Specify the programme mode. Select the title XY GRAPH. (Drawing of graph)	2nd F PRGM A *	

Ordinary Differential Equations

Enter the initial conditions (X, Y) with the step H and interval T. Use Runge Kutta Gill method to solve the ordinary differential equation of first order.

Calculation

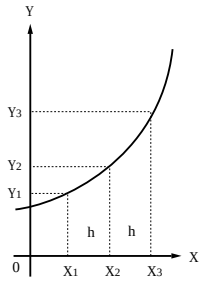
Use the following four steps of Runge Kutta Gill method to find the equation X_{n+1} and Y_{n-1} from X_n and Y_n. Input $Q_0 = 0$ at the starting point X_0.

1. $K_0 = Hf(X_n, Y_n)$, $R1 = (1/2)(K_0 - 2Q_0)$, $Y^{(1)} = Y_n + R_1$

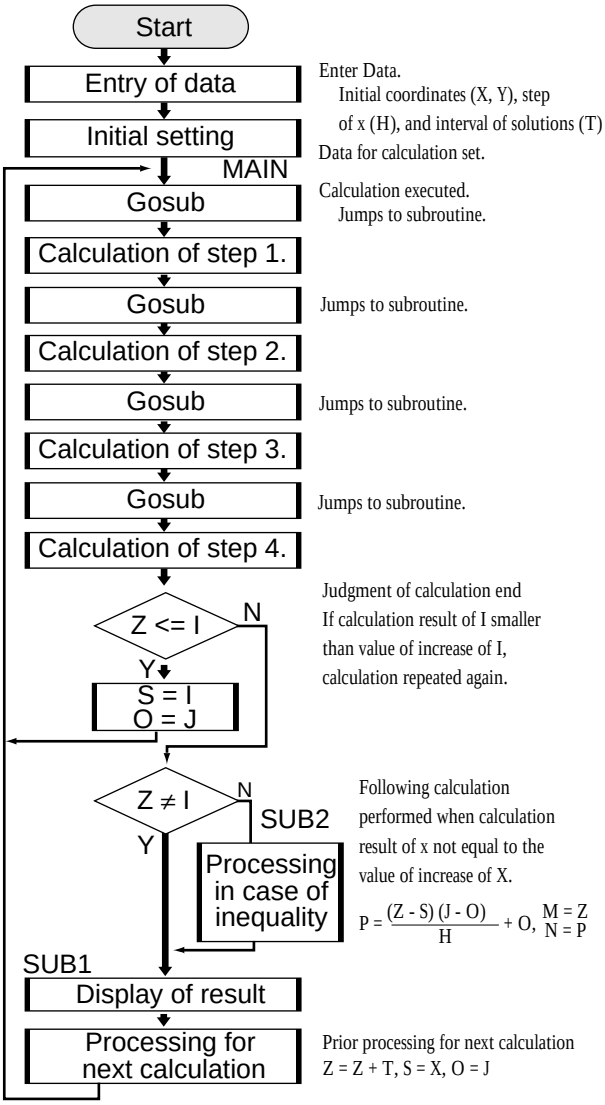
2. $Q_1 = Q_0 + 3R_1 - (1/2)K_0$
   $K_1 = Hf(X_n + H/2, Y^{(1)})$, $R_2 = (1 - \sqrt{1/2})(K_1 - Q_1)$, $Y^{(2)} = Y^{(1)} + R_2$

3. $Q_2 = Q_1 + 3R_2 - (1 - \sqrt{1/2})K_1$
   $K_2 = Hf(Xn + H/2, Y^{(2)})$, $R_3 = (1 + \sqrt{1/2})(K_2 - Q_2)$, $Y^{(3)} = Y^{(2)} + R_3$

4. $Q_3 = Q_2 + 3R_3 - (1 + \sqrt{1/2})K_2$
   $K_3 = Hf(X_{n+1}, Y^{(3)})$, $R_4 = (1/6)(K_3 - 2Q_3)$, $Y_{n+1} = Y^{(3)} + R_4$
   $Q_4 = Q_3 + 3R_4 - (1/2)K_3$



FLOWCHART



Enter Data.
Initial coordinates (X, Y), step of x (H), and interval of solutions (T)
Data for calculation set.

Calculation executed.
Jumps to subroutine.

Jumps to subroutine.

Jumps to subroutine.

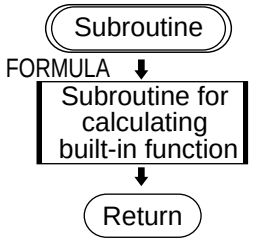
Jumps to subroutine.

Judgment of calculation end
If calculation result of I smaller than value of increase of I, calculation repeated again.

Following calculation performed when calculation result of x not equal to the value of increase of X.

$P = \frac{(Z - S)(J - O)}{H} + O$, $\frac{M = Z}{N = P}$

Prior processing for next calculation
Z = Z + T, S = X, O = J



Subroutine for calculating built-in function

f = -I ∗J
(Another equation can be used.)

PROGRAMME LIST(REAL MODE)

Title : RUNGE

```
Rem INITIAL
Print " Input X0
Input X
Print " Input Y0
Input Y
X⇒I
Y⇒J
Print " Input H
Input H
Print " Input T
Input T
1+√(2^-1)⇒A
1- √(2^-1)⇒B
I+T⇒Z
O⇒Q
I⇒S
Label MAIN
Rem 1
Gosub FORMULA
H∗F⇒K
(K-2∗Q) /2⇒R
J+R⇒J
Q+3∗R-K/2⇒Q
I+H/2⇒I
Rem 2
Gosub FORMULA
H∗F⇒K
B∗(K-Q)⇒ R
J+R⇒J
Q+3∗R-B∗K⇒Q
Rem 3
Gosub FORMULA
H∗F⇒K
A∗(K-Q)⇒ R
J+R⇒J
Q+3∗R - A∗K⇒Q
I+H/2⇒I
Rem 4
Gosub FORMULA
H∗F⇒K
(K - 2∗Q) /6⇒R
J+R⇒J
Q+3∗R - K/2⇒Q
If Z≤I Goto NEXT
I⇒S
J⇒O
Goto MAIN
Label NEXT
If Z≠I Goto SUB2
I⇒M
J⇒N
Label SUB1
ClrT
Print "XN=
Print M
Print "YN=
Print N
Wait
Z+T⇒Z
I⇒S
J⇒O
Goto MAIN
Label SUB2
(Z-S)∗(J-O) /H+O⇒P
Z⇒M
P⇒N
Goto SUB1
Label FORMULA
-I∗J⇒F
Return
```


SHARP

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	value of $1+\sqrt{(1/2)}$	S	value of Xn-1
B	value of $1-\sqrt{(1/2)}$	T	interval
F	f (I,J)	I	Xn
H	step	J	Yn
K	calculating working area	Z	value of increase of X
O	value of Yn-1	X	input of X_0
P	increase of J	Y	input of Y_0
Q	value of Qn	M	indicates Xn
R	value of Rn	N	indicates Yn

Exercise

Initial settings: Y = 10 when X = 0. Find J when H = 0.01, T = 0.03 and I = 0.03, 0.06···.
(The built-in differential equation is F = -I ∗ J.)

Set up condition: angle unit in Rad Mode and decimal point in Float Pt Mode.

[2nd F] [SET UP] [B] ∗ [2] ∗ [C] ∗ [1] ∗ [CL]

Step	***Key Operation***	***Display*** (When using EL-9600)
1 Specify the programme mode. Select the title RUNGE.	[2nd F] [PRGM] [A] ∗	RUNGE Input X0 X=?
2 Enter the values of X_0, Y_0, H and T.	[0] [ENTER] [1] [0] [ENTER] [0] [•] [0] [1] [ENTER] [0] [•] [0] [3] [ENTER]	RUNGE Input X0 X= 0 Input Y0 Y= 10 Input H H= 0.01 Input T T= 0.03
3 (Display of X1) (Display of Y1)	[ENTER]	XN= .03 YN= 9.995501012
4 (Display of X2) (Display of Y2)	[ENTER]	XN= .06 YN= 9.98201619
5 (Display of X3) (Display of Y3)	[ENTER]	XN= .09 YN= 9.959581902

Similar operation is performed hereafter.

Analysing with One-way Layout Method

Use the one-way layout method to verify whether there is a relation to the results achieved based on one condition. Analysis of variance is carried out with this method.

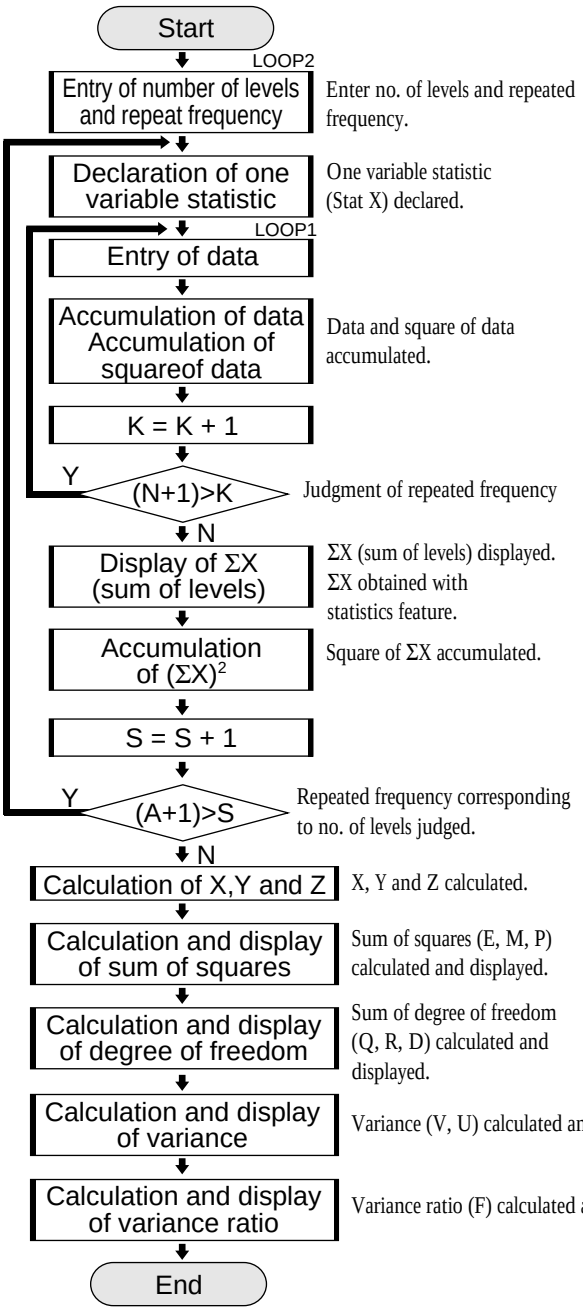
Calculation

Analysis of variance chart of one-way layout method

	Sum of squares (S)	Degree of freedom (θ)	Variance (V)	Variance ratio (F)
Factor	S_A = [A] - [X]	θ_A = A - 1	$V_A = S_A \div \theta_A$	$F_A = V_A \div V_E$
Error	S_E = [AS] - [A]	θ_E = A (N- 1)	$V_E = S_E \div \theta_E$	
Total	S_T = [AS] - [X]	θ_T = AN - 1		

$[X] = (\Sigma\ \Sigma\ Xij)^2 \div AN$
$[A] = \Sigma i\ (\Sigma j\ Xij)^2 \div N$
$[AS] = \Sigma i\ \Sigma j\ (Xij)^2$
A : number of levels
N : repeated frequency
X : number of data

FLOWCHART



PROGRAMME LIST(STAT MODE)

Title : VARIANCE

```
Rem INPUT
Print "Input LEVEL
Input L
L⇒A
Print "Input TIMES
Input T
T⇒N
0⇒W
0⇒B
0⇒C
1⇒S
Label LOOP2
N⇒dim(L1)
1⇒K
Label LOOP1
ClrT
S⇒L
K⇒T
Print "Input DATA
Print "LEVEL
Print L
Print "TIME
Print T
Input I
I⇒L1(K)
B+I⇒B
C+I²⇒C
K+1⇒K
If (N+1)>K Goto LOOP1
1_Stats L1
Σx⇒J
Print "Σx=
Print J
Wait
W+(Σx)²⇒W
S+1⇒S
If (A+1)>S Goto LOOP2
Rem CALCULATE
B²/A/N⇒X
W/N⇒Y
C⇒Z
Rem SUM OF SQUARES
Y-X⇒E
Z-Y⇒M
Z-X⇒P
Print "SUM OF SQUARES
Print E
Print "ERROR SUM OF SQUARES
Print M
Wait
Print "TOTAL SUM OF SQUARES
Print P
Wait
Rem DEGREES OF FREEDOM
A-1⇒Q
A∗(N-1)⇒R
A∗N-1⇒D
Print "DEGREES OF FREEDOM
Print Q
Print "DEGREES OF FREEDOM ──┐
Print R                     ↳ABOUT ERRORS
Wait
Print "SUM OF DEGREES OF FREEDOM
Print D
Wait
Rem VARIANCE
E/Q⇒V
M/R⇒U
Print "VARIANCE
Print V
Print "VARIANCE OF ERRORS
Print U
Wait
Rem VARIANCE RATIO
V/U⇒F
Print "VARIANCE RATIO
Print F
End
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	number of levels	V	variance factor
I	input of data	U	variance error
K	loop 1 counter	Y	$\Sigma i\ (\Sigma\ jxij)^2 / n$
J	indicating Σx	Q	degree of freedom factor
N	repeated frequency	R	degree of freedom error
S	loop 2 counter	D	degree of freedom total
X	$(\Sigma\Sigma\ xi)^2 / a / n$	T	input and indicating frequency
Z	$\Sigma i\ \Sigma j\ (xij)^2$	L	input and indicating number of levels
F	variance ratio factor	W	total sum of squares of each level
E	sum of squares factor	B	total sum (all data)
M	sum of squares error	C	stotal sum of squares (all data)
P	sum of squares total		

Exercise

When a mouse is given a dosage of hormone, the relationship between dosage amount and increase of mouse weight is as shown in the following table. Find the analysis of variance. If the value of the variance ratio is larger than the value of F- distribution table of the 5% level of significance, the relationship between the hormone amount and the increase of mouse weight is a causal relation.

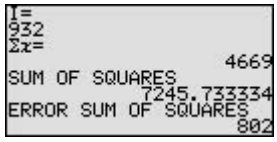
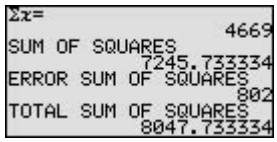
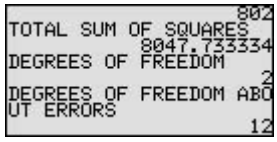
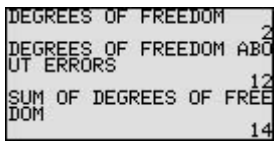
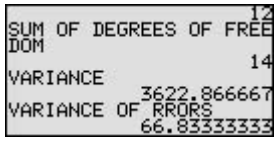
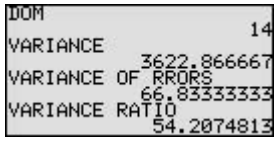
	Increase mouse weight (grams/day)					
		10	20	30	40	50
Hormone (grams/mouse)	10	882	891	864	888	885
	20	923	915	923	912	930
	30	933	939	925	940	932

The number of levels (number of columns in the table) is A = 3
The repeated frequency (number of rows in the table) is N = 5

Set up condition: decimal point in Float Pt Mode.

[2nd F] [SET UP] [C]* [1]* [CL]

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title VARIANCE.	[2nd F] [PRGM] [A]*	VARIANCE Input LEVEL L=?
2 Enter the number of levels and the repeated frequency.	[3] [ENTER] [5]	VARIANCE Input LEVEL L= 3 Input TIMES T= 5
3	[ENTER]	Input DATA LEVEL 1 TIME 1 I=?

Step	Key Operation	Display (When using EL-9600)
4 Enter the statistical data in level 1.	8 8 2 ENTER 8 9 1 ENTER 8 6 4 ENTER 8 8 8 ENTER 8 8 5 ENTER	
(Display of total of hormone 10 g)		
5 Enter the statistical data in level 2.	ENTER 9 2 3 ENTER 9 1 5 ENTER 9 2 3 ENTER 9 1 2 ENTER 9 3 0 ENTER	
(Display of total of hormone 20 g)		
6 Enter the statistical data in level 3.	ENTER 9 3 3 ENTER 9 3 9 ENTER 9 2 5 ENTER 9 4 0 ENTER 9 3 2 ENTER	
(Display of total of hormone 30 g)		
7	ENTER	
(Display of sum of squares) (Display of error sum of squares)		
8	ENTER	
(Display of sum of squares)		
9	ENTER	
(Display of degrees of freedom) (Display of degrees of freedom about errors)		
10	ENTER	
(Display of sum of degrees of freedom)		
11	ENTER	
(Display of variance) (Display of variance of errors)		
12	ENTER	
(Display of variance ratio)		

The F-distribution chart shows that the value of F of upper probability P = 5% is 3.89. Since f > 3.98 in this example, the relationship between the hormone amount and the increase of mouse weight is a causal relation with 5% level of significance.

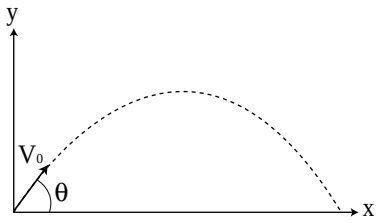
Calculating Parabolic Motion

Display on a graph the altitude change and the horizontal distance over a period of time when an object is thrown at initial velocity V_0 and angle θ, and find the horizontal distance and altitude after t seconds. Specify the angle in Deg.

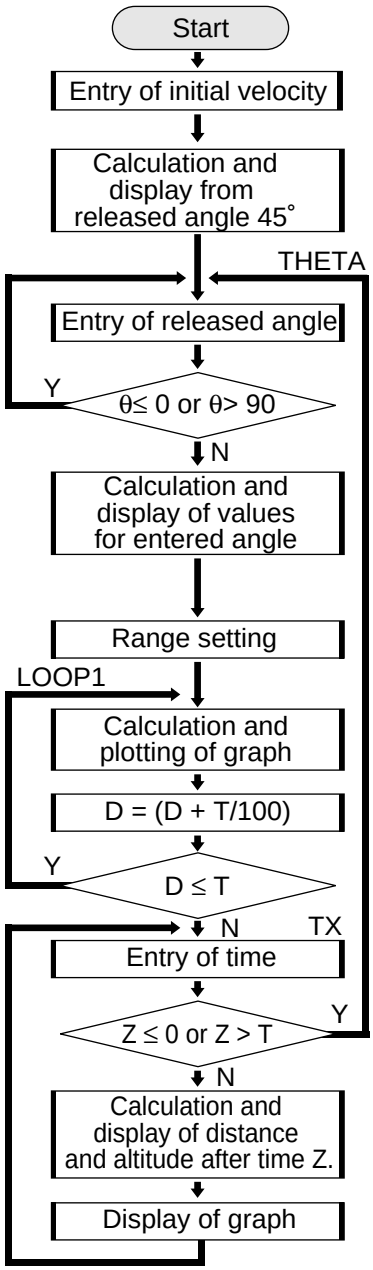
Calculation

$X = V_0 \cdot \cos\theta \cdot T \qquad Y = V_0 \cdot \sin\theta \cdot T - \frac{1}{2} gT^2$

Initial velocity	V_0 [m/s]
Angle	θ [˚]
Gravitational acceleration	g = 9.8 [m/s^2]
Time	T [s]



FLOWCHART



Enter velocity when thrown.

Highest altitude, throwing distance (horizontal distance), and time (duration of flight) in case of released angle 45˚ calculated and displayed.

Angle for throwing entered.

Entered angle less than or equal to 0˚ or larger than 90˚?

Highest altitude, throwing distance (horizontal distance), and time (duration of flight) for entered angle calculated and displayed.

Range of graph set based on values for released angle 45˚.

Graph (parabola) calculated and plotted.

Elapsed time counted.

Calculation and plotting repeated until D (time elapsed) reaches T (duration of flight).

Entered time less than or equal to 0 or more than T?

Altitude and distance after entered time elapses from throwing calculated and displayed.

Returns to entry of time.

PROGRAMME LIST(REAL MODE)

Title : PARABOLA

```
Print "V0 (M/S),θ,T(S)
Print "Input V0
Input V
2∗V∗sin 45/9.8⇒A
V²/9.8⇒B
V²/19.6⇒C
Print "HMAX=
Print C
Print "LMAX=
Print B
Print "TMAX=
Print A
Wait
Label THETA
Input θ
If θ ≤ 0 Goto THETA
If θ > 90 Goto THETA
V²∗(sin θ)²/19.6⇒H
V²∗sin (2θ)/9.8⇒L
2∗V∗sin θ/9.8 ⇒T
Print "H=
Print H
Print "L=
Print L
Print "T=
Print T
Wait
C/10⇒Yscl
B/10⇒Xscl
0⇒Xmin
0⇒Ymin
B⇒Xmax
C⇒Ymax
0⇒D
Label LOOP1
V∗cos θ∗D⇒X
V∗sin θ∗D-(0.5∗9.8∗D²)⇒Y
Pnt0N(X,Y)
D+(T/100)⇒D
If D≤T Goto LOOP1
Wait
Label TX
Print "Input TX
Input Z
If Z≤0 Goto THETA
If Z>T Goto THETA
V∗cos θ∗Z⇒X
V∗sin θ∗Z-(0.5∗9.8∗Z²)⇒Y
Print "X=
Print X
Print "Y=
Print Y
Wait
Line(0,Y,X,Y)
Line(X,0,X,Y)
Wait
Goto TX
0000
```

PARAMETERS

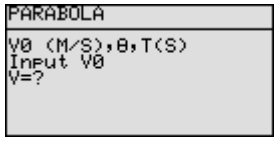
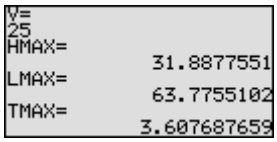
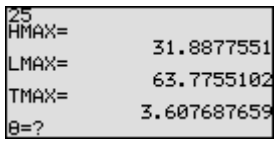
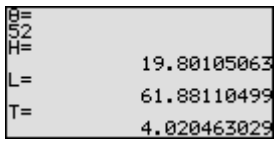
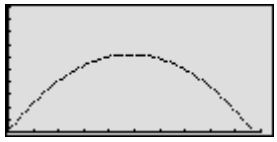
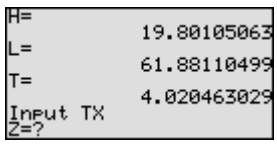
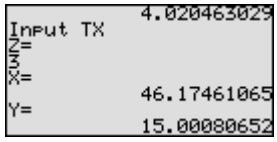
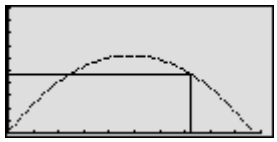
Name of parameter	Content	Name of parameter	Content
H	highest altitude	Xscl	scale of x-coordinate
L	horizontal distance	Z	input of time period
T	time	V	initial velocity (V_0)
X	distance (after time Z)	θ	angle (released angle)
Y	altitude (after time Z)	C	highest altitude when released at 90°
D	time elapsed	B	horizontal distance when released at 45°
Yscl	scale of y-coordinate	A	time period when released at 45°

Exercise

Find the horizontal distance and altitude three seconds after an object is thrown, when the initial velocity is 25m/sec and the angle is 52°.

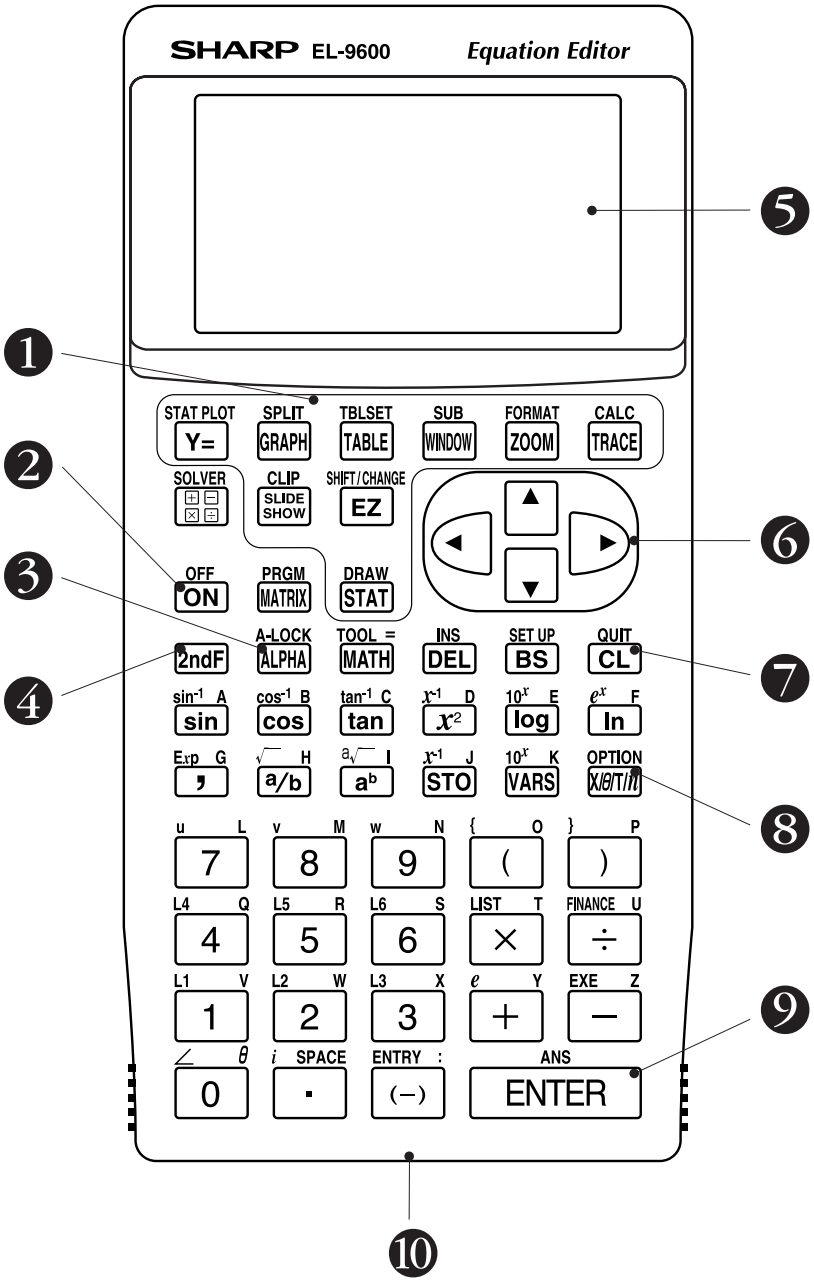
Set up condition: angle unit in Deg mode, and decimal point in Float Pt mode.

[2nd F] [SET UP] [B] * [1] * [C] * [1] * [CL]

Step	Key Operation	Display (When using EL-9600)
1 Specify the programme mode. Select the title PARABOLA.	[2nd F] [PRGM] [A] *	
2 Enter the value of the initial velocity. (Highest altitude when released at 90°) (Distance when released at 45°) (Time when released at 45°)	[2] [5] [ENTER]	
3	[ENTER]	
4 Enter the angle value. (Display of highest altitude) (Display of horizontal distance) (Display of time until dropping of object)	[5] [2] [ENTER]	
5 (Display of graph of parabola)	[ENTER]	
6	[ENTER]	
7 Enter the value of time period Z. (Display of distance after Z seconds) (Display of altitude after Z seconds)	[3] [ENTER]	
8 (Altitude and distance after Z seconds are displayed on the parabola graph.)	[ENTER]	

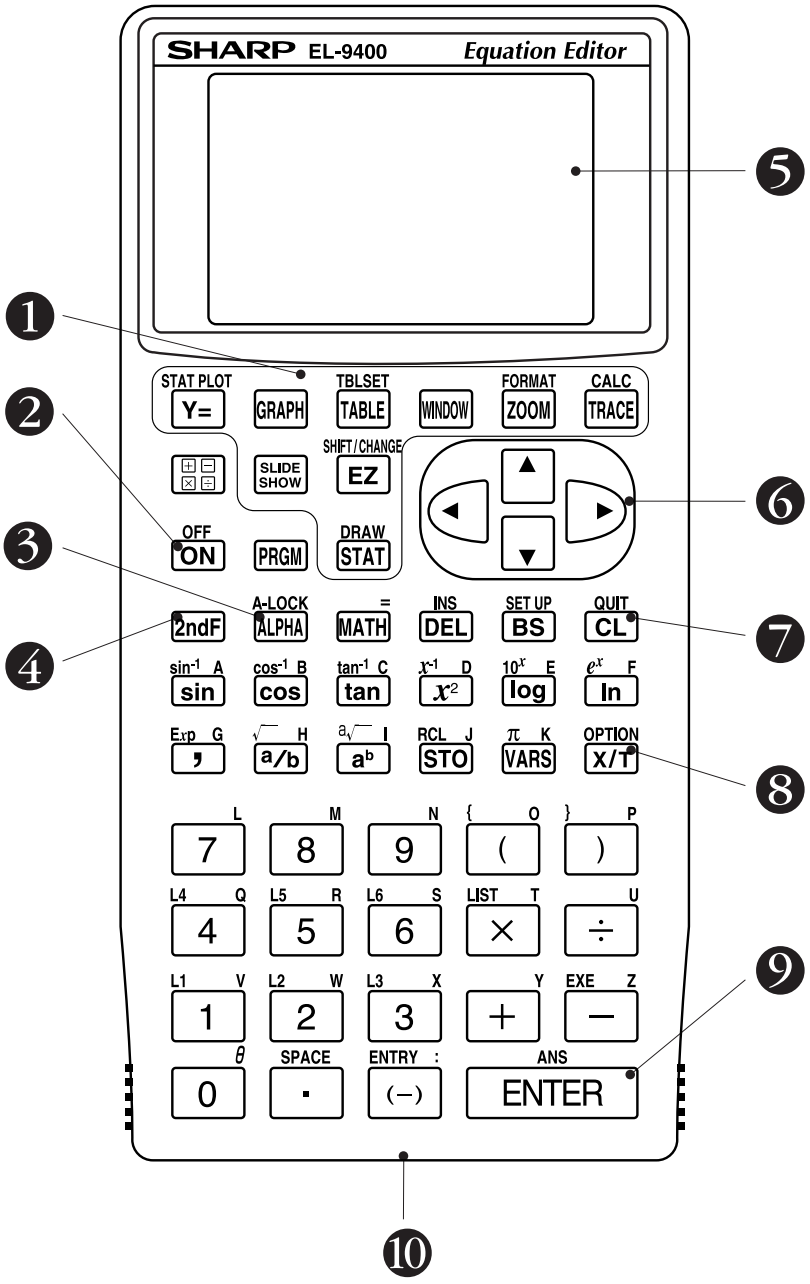
SHARP

Key pad for the SHARP EL-9600 Calculator



1. Graphing keys
2. Power supply ON/OFF key
3. Alphabet specification key
4. Secondary function specification key
5. Display screen
6. Cursor movement keys
7. Clear/Quit key
8. Variable enter key
9. Calculation execute key
10. Communication port for peripheral devices

Key pad for the SHARP EL-9400 Calculator



1. Graphing keys
2. Power supply ON/OFF key
3. Alphabet specification key
4. Secondary function specification key
5. Display screen
6. Cursor movement keys
7. Clear/Quit key
8. Variable enter key
9. Calculation execute key
10. Communication port for peripheral devices

SHARP

Use this form to send us your contribution

Dear Sir/Madam

We would like to take this opportunity to invite you to create a mathematical problem which can be solved with the SHARP EL-9600 and 9400 graphing calculator, including the necessary procedures and definitions as outlined in the form below.

For this purpose, we would be grateful if you could complete the form and return it to us by fax or mail, specifying whether you have created the problem for the EL-9600 or the EL-9400. If your contribution is chosen, your name will be included in the next edition of The EL-9600/9400 Graphing Calculator Handbook or on our homepage. We regret that we are unable to return contributions. Also, please note that the problems you send us might be opened to the public at Sharp's home page.

We thank you for your cooperation in this project.

Name: (☐ Mr. ☐ Ms.)

School/College/Univ.:

Address:

Post Code: Country:

Phone: Fax:

E-mail:

* You are making this sheet for the (☐ EL-9600, ☐ EL-9400).

SUBJECT: Write either a title or about the subject matter.

. . . . . .

INTRODUCTION and CALCULATION:
Write a brief explanation of the subject, and the formula with definitions, including a diagram if relevant.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

PARAMETERS:

Define the parameters used in the programme.

PROGRAMME LIST:

List the procedure of data to be entered.

EXERCISE and SET UP CONDITION:

Include an example of a problem which can be solved with the formula. Write a step-by-step guide to solving the problem with an explanation.Detail any important conditions to be set up before solving the problem.

SHARP

SHARP CORPORATION Osaka, Japan
Fax:

SHARP

SHARP CORPORATION OSAKA,JAPAN

FAX:06-628-1653